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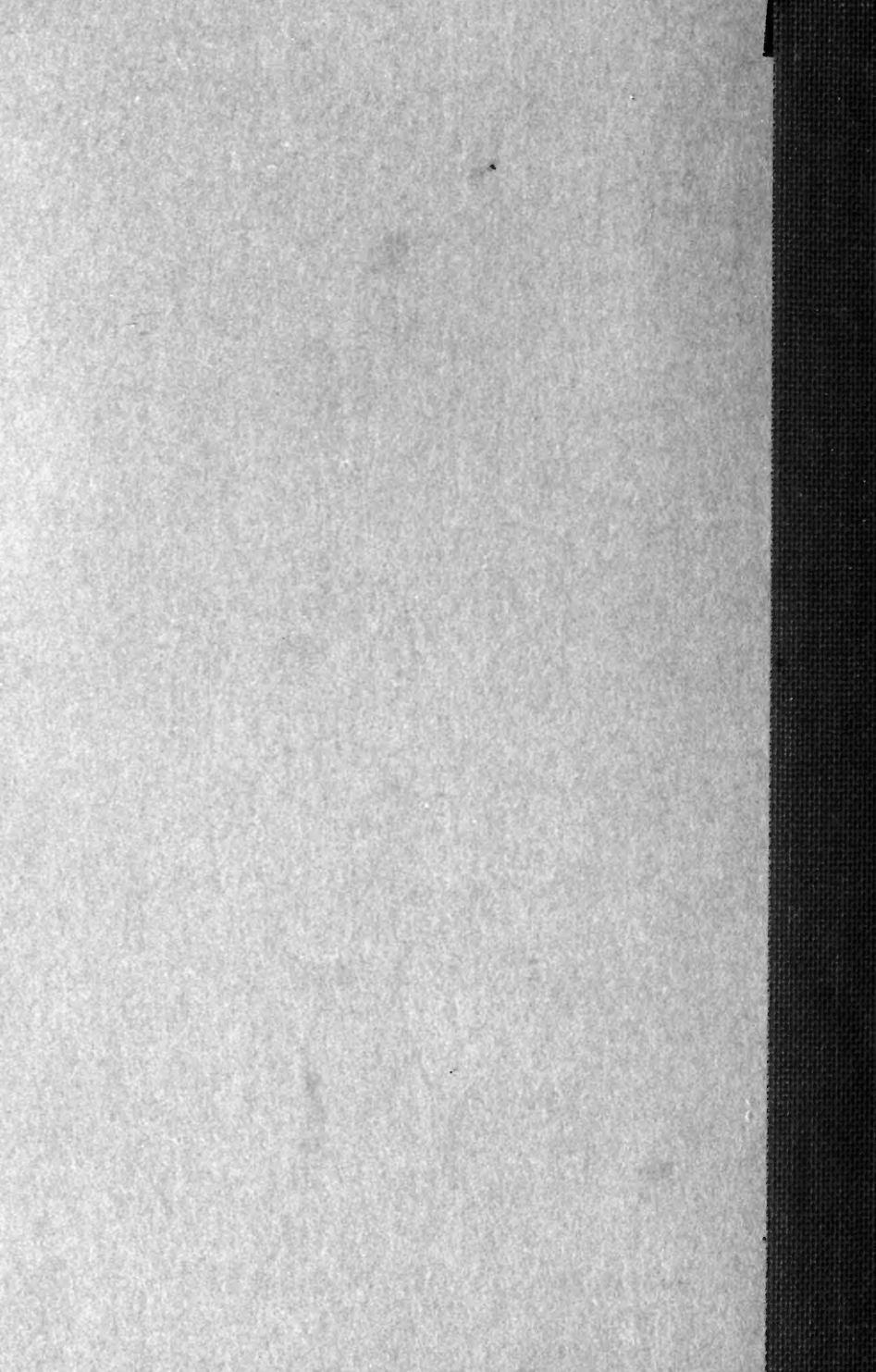
U.S. Forest Service  
Instruction for making  
forest surveys and maps. Rev.

SD

361

U5

1912



*U.S. Forest Service*  
**UNITED STATES DEPARTMENT OF AGRICULTURE**

**FOREST SERVICE**

**HENRY S. GRAVES, FORESTER**

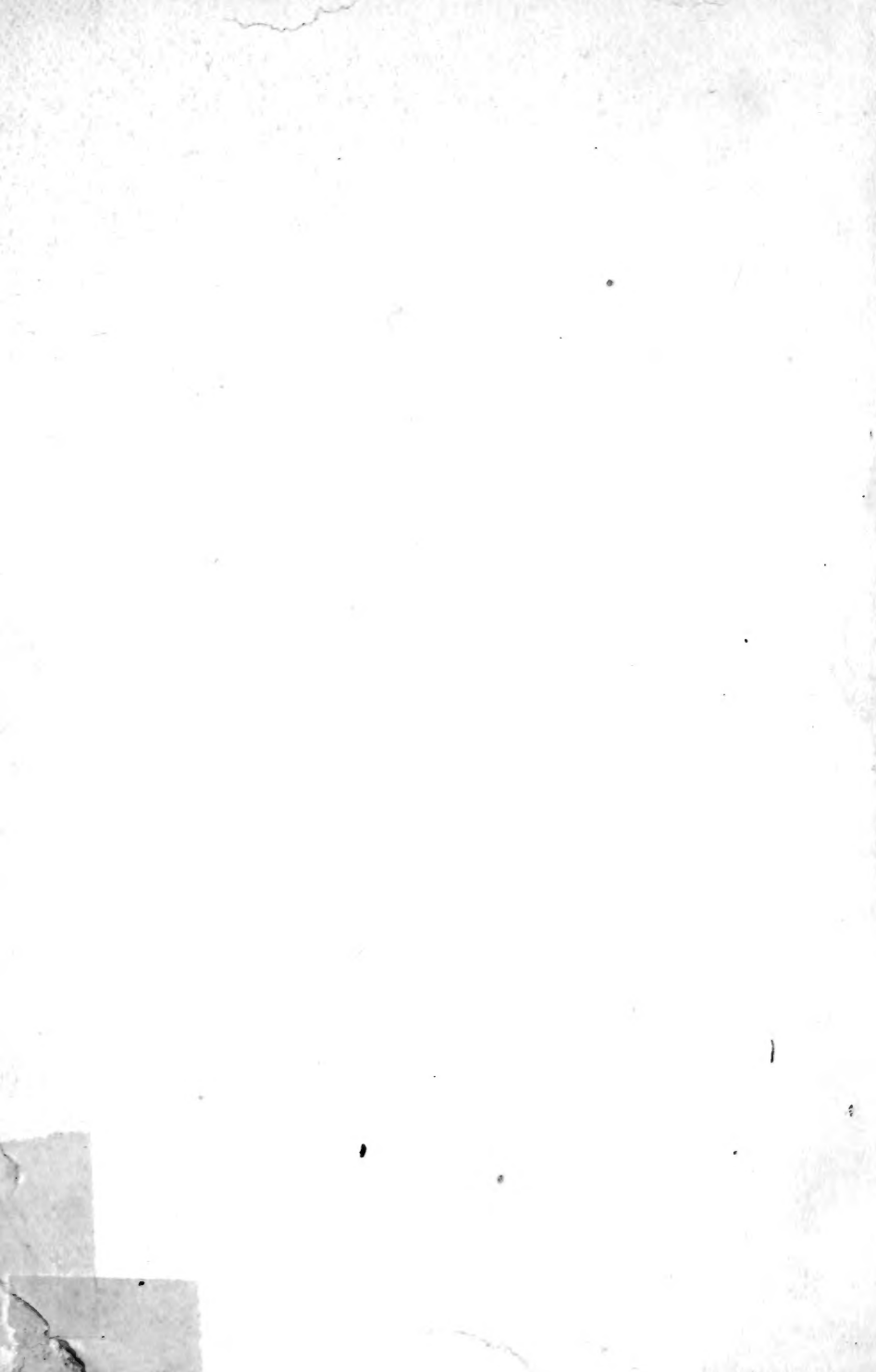
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**INSTRUCTIONS FOR MAKING  
FOREST SURVEYS  
AND MAPS**

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**1912**

Revised and reissued 1915



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U. S. DEPARTMENT OF AGRICULTURE,

U. S. FOREST SERVICE.

HENRY S. GRAVES, FORESTER.

# INSTRUCTIONS FOR MAKING FOREST SURVEYS AND MAPS.

REVISED DECEMBER 15, 1911.

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PREPARED IN THE OFFICE OF GEOGRAPHY.



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# INSTRUCTIONS FOR MAKING FOREST SURVEYS AND MAPS.

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## ELEMENTS OF SURVEYING AND MAPPING.

These simple instructions are issued to members of the Forest Service in order that forest surveys and maps may be as nearly uniform as practicable. They do not include directions for the use of instruments of great precision, and the tables are prepared only to such accuracy as is attained in careful timber cruising or in surveying with the magnetic compass. This is  $\frac{1}{4}^{\circ}$  or 15' of arc.<sup>1</sup>

Forest surveys are made for two purposes—to locate and mark lines or boundaries upon the ground, or to furnish data for the preparation of maps.

The correctness of a survey depends upon the excellence of the instruments in use and the skill of the surveyor and his party. A skillful surveyor can do better work with poor instruments than an unskilled or careless one with the best instruments. Small instrumental

---

<sup>1</sup> The "diurnal" or daily change of a magnetic needle, which is one of the variations for which allowance is made in precise surveying, amounts to 10' or 15', and the influence of magnetic storms upon the needle is frequently unsuspected at the time a survey is made.

Clinometers and clinometer compasses, by which the degree of a slope or a vertical angle may be measured, are generally read only to the nearest  $\frac{1}{2}^{\circ}$  or  $\frac{1}{4}^{\circ}$ .

Members of the Forest Service who are using solars, transits, levels, etc., have received training and experience in the care and use of such instruments, and can execute the necessary surveys of precision. They are provided with advanced manuals of surveying and construction, tables, ephemerides, etc.

errors usually balance themselves, and they are quickly discovered by the trained operator, who will know how to make allowance for them, if necessary. The unskilled or careless man will sometimes read the wrong end of the compass needle; read the graduated ring dial from the wrong direction; make a mistake in entering the reading in his notebook, or perpetrate some other palpable blunder which will throw doubt over the whole work and make a resurvey necessary.

Certain fundamental principles underlie all surveys. We may assume a piece of land the location, extent, and contour of which are unknown. First of all the survey should determine its location, shape, and area, and if necessary its topography, and any other essential data. As in logic, one should start from something which is known to determine something which is unknown. The line which connects an unknown point with a known point is called a *tie*, and as soon as the tie is run the position of the unknown point is established. A line run around a tract of land is called a *boundary line*, and the angles on this line are called corners, stations, posts, or stakes, according to the local or established terms. It is not always necessary to run the boundaries of a tract to determine its position and area. A base line might be run across it with ordinates on either side extending to the limits of the tract. Or if the tract is a small watershed, lines might be traversed up all of the streams and drainage lines, or the area might be divided into squares and fractions of squares, similar to land-survey sections. Still another way will be described under the head of "Plane table."

The method to be employed depends upon the purpose of the survey, but no matter what method is used, the survey will fail in its primary purpose if it does not show the location, position, form, and size of the tract surveyed.

### INSTRUMENTS USED.

Three kinds of instruments are used in surveying, viz: For determining *azimuth* or horizontal angles; for determining grade or *vertical angles*; for determining *distances*. The horizontal deflection of a line is always expressed in *degrees*. The vertical deflection of a line is generally expressed in *per cent*. The length of a line in Government land surveying is always expressed in *chains* (66 feet). The *altitude* above sea level is expressed in *feet*.

The principal instrument for determining azimuth is the magnetic compass, which, although of very simple construction, will be absolutely misleading to anyone who uses it without understanding. Suppose, for instance, a good compass, manufactured and adjusted in some eastern factory or in Europe, should be taken to the Pacific coast. It would undoubtedly indicate the direction of the magnetic currents at any time and place that it might be used, but its needle would not point north and south and probably would not hang level on the center pivot. The latter defect is quickly remedied by moving a little sliding weight, which should be on the south end of the needle.

Sight compasses are constructed so that they may be sighted upon a distant object and the magnetic direction is determined by reading the degree indicated on the ring dial by the north end of the needle.

Vernier compasses are provided with a revolving graduated ring dial which may be set according to the magnetic variation, thus reducing the reading to true north instead of magnetic north.

Clinometer compasses are provided with a small pendulum hung from the center pivot, which is used to determine a vertical angle.

Prismatic compasses are sight compasses with a "floating" dial which may be held in the hand. The sight is taken and the direction is read in the same operation.

Mirror compasses are provided with a reflecting surface on the inside of a hinged cover, and the reflection of the reading is noted at the time the sight is taken.

Alidade compasses are provided with at least one straight edge parallel to the line of sight. The bottom of the compass is smooth so that the instrument may be laid upon a map and the straight edge used as a ruler.

Solar compasses are provided with a special attachment which can be revolved independent of the compass for taking observations on the sun and determining the cardinal direction without using the compass needle.

Compasses are also used as a part of the equipment of transits, levels, and plane tables, and in such cases these instruments should be constructed of nonmagnetic materials, in order that the needle may not be deflected. Iron, nickel, cobalt, and manganese are the most magnetic substances.

The instruments for determining grade or vertical angles are:

The grademeter;

The Locke hand level; and

The Abney reflecting level, which is provided with a vertical arc, graduated either to per cent, degrees, or ratio of slope, according to the purpose for which it is used.

The unit of land measure is the standard surveyor's chain of 66 feet. For some classes of work steel band chains or steel tapes are found more convenient and economical, because they are lighter and greater lengths can be dragged over the ground, thus effecting a saving in pinning and tallying. Tapes are usually graduated in feet, and when they are used it is necessary to reduce the measurements to standard chains, in order that they may conform with the official land surveys. In some regions the best means for determining distances are the stadia transit and rod. These instruments are used by specially trained men, and are therefore not described here.

#### **FOREST SERVICE STANDARD COMPASS.**

Figure 1 shows the surveying compass which has been adopted by the Forest Service for the use of field men in making forest surveys and maps. Very accurate work can be done with this instrument if properly used, and for this reason requisitions for transits should not be made unless there is a special need for using a still higher grade instrument. The principal features of this standard compass are as follows:

The sights are very tall, and therefore admit of use on steep hillsides or in taking observations on Polaris. The hair sight may be repaired easily by threading through the holes at *A* and *B*. If after long use the

sights work too freely they may be tightened by the nut *C*.

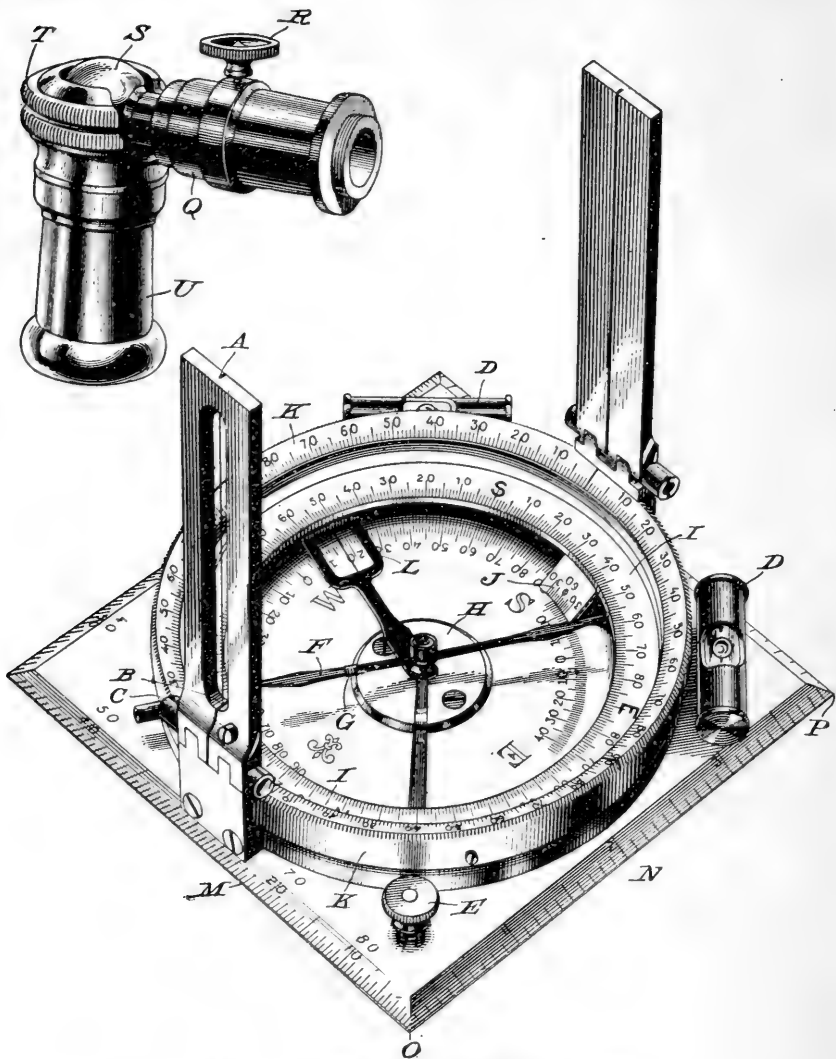


FIG. 1.—Forest Service standard compass.

The base of the instrument is an accurate square, beveled and graduated as a protractor on two sides



and to inch scales on two sides. One of these scales is Forest Atlas standard of 1 inch to 1 mile, and is divided into eighths, each of which represents 10 chains. The other scale is decimal. The base supports two levels, *D*, set at right angles to each other, each being adjustable by means of small screws and a center point on which they rock.

The clamp *E* is a milled nut which operates to lift the needle from the center pin when the compass is not in use. It works so easily on a screw that the azimuth of the instrument need not be disturbed when the needle is unclamped or clamped. The thread is riveted on the top so that the nut will not come off and be lost.

The needle *F* is of blue steel and is provided on its south end with a small brass weight, which may be pushed toward or away from the center if it becomes necessary to make the needle hang horizontal and counteract the magnetic dip in any locality. Of course the needle should be removed from the center pivot when this is done. The base dial is reenforced at *H* to hold the center pivot more securely. It is engraved to show (1) the cardinals, (2) a half circle of degrees for the clinometer, and (3) 70° of variation, including east and west. The ring dial *I* is graduated to degrees reading from zero°, from north and south, to 90° at east and west. It carries a vernier, *J*, which reads against the variation graduation on the base dial. The cover is of heavy plate glass and is held in place by a graduated and slotted rim, *K*, which also revolves in azimuth.

The clinometer consists of a weighted pendulum, *L*, which hangs on the center pivots and is provided with

a pointer which reads against a graduation on the base dial.

The edges  $M$  and  $N$  are perpendicular to each other, and the line  $OP$  is parallel to the line of sight and may, therefore, be used as an alidade.

The above description covers that portion of the instrument which is used upon a plane table either for ordinary compass work or for mapping on the plane-table sheet. The instrument is, however, provided with a ball-and-socket attachment so that it may be used upon a Jacob staff, tripod, or more conveniently held in the hand if used as a hand compass for rough cruising. These parts are shown in the illustration;  $Q$ , a cone-bearing containing the spindle, which may be clamped by the screw  $R$ ; the ball  $S$  is held by the socket cover  $T$ , which screws upon the mounting  $U$ .

When this instrument is used on the plane table the proceeding is as follows:

The sights having been raised and the instrument laid on the table, the table is leveled by observing the bubbles. The variation having been set off, the table is oriented with the compass needle, which should read zero at the north end. Then sights may be taken upon all the objects to be mapped, using the edge  $OP$ , or the opposite parallel edge, as an alidade. The distances may be measured with the scale.

When used as a surveyor's compass the leveling is done by means of the ball and socket  $S$  and  $T$ , and the compass is revolved in azimuth by loosening the clamp screw  $R$ .

As a clinometer for measuring vertical angles, the edge  $M$  may be laid upon a slope and the pendulum

will show the number of degrees of dip or rise. This is not the same as "per cent of grade." The difference is shown on page 40. Another method is to lay the edge *M* on the level plane-table board and, revolving the rim vertically, take a sight through the slots *K*. The angle of dip or rise may then be very closely approximated by reading the graduation on the rim. In some of these instruments the cover of the socket, at the ball joint, is cut away on one side, permitting the spindle to be tipped over and the compass revolved in a vertical plane. The sights may then be used in connection with the clinometer. This altered socket will be issued when specially requisitioned.

Right angles may be turned accurately without the use of the compass by two methods: (1) By drawing a line on the plane-table sheet on the edges *O P* and then turning the instrument  $90^\circ$  until the edge *M* coincides with the line, or (2) the slots *K* may be used without moving the instrument, as they are placed exactly  $90^\circ$  apart.

This instrument should give good results if used and treated with the care which is necessary for any well-made and carefully adjusted instrument. The custodian should keep it clean, but should not oil it, though it may be wiped occasionally with a slightly greasy piece of muslin. The needle should always be clamped when not in use, and the hair sight should always be closed down first so that it will be protected by the slot sight. The cover glass may be removed by taking off the sights and then the surrounding rim, which is provided with small brass screws which travel in a channel cut into the outside of the compass box. It is

not necessary to remove the glass in order to sharpen the center pivot. This may be done by unscrewing it from the under side of the compass after the needle has been clamped, although this must be done very carefully, so that the clinometer pendulum will not move out of place; otherwise it will be necessary to remove the cover glass.

In case of any serious injury to any instrument, it should be returned to the property clerk at Ogden for repairs.

The instrument should not be kept near large bodies of iron, nor exposed to electric motors or generators. Compass needles are frequently demagnetized by being carried in a valise in an electric car and being set down over a powerful motor, because the needle is clamped (as it should be) while being carried. On the other hand, the magnetism of a needle may be strengthened by laying the compass, with the needle unclamped, near a direct-current motor or generator or strong magnet. A better plan is to unclamp the needle, and after it has found its bearing, to clamp it and leave it to the influence of the magnetic current. In this way the continued quiver of the needle will not dull the center pivot.

Do not allow the needle to be deflected, while being read, by an ax, jackknife, pencil tip, the metal band of a hat, or other metal.

#### THE POCKET COMPASS.

The Forest Service standard pocket compass is a strong and serviceable instrument for cruising or re-tracing survey lines. Instructions for its proper use are engraved upon the base dial, as shown in figure 2.

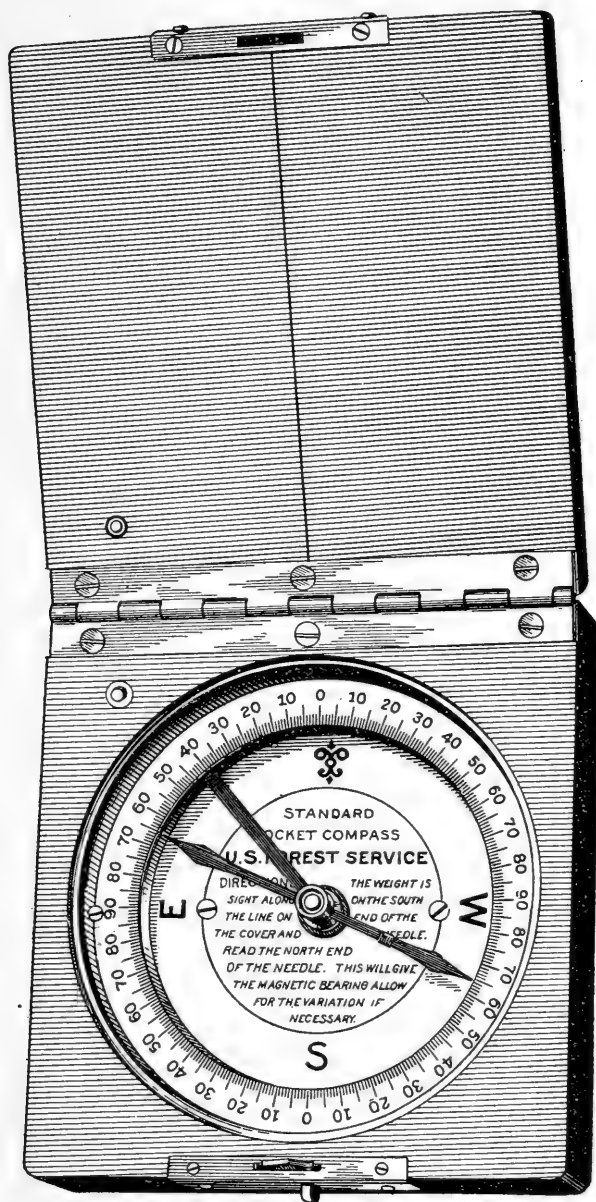


FIG. 2.—Standard pocket compass.

### MAGNETIC NEEDLE.

It is unfortunate that all makers of surveying instruments do not have a uniform method of designating the north or south end of compass needles, but that the surveyor must learn and remember whether the blue or white, or the weighted or cross-barred end of the needle is the one which points northward. Some small compasses also differ in the positions of the E. and W. according to the use which is to be made of them. If they are to be used as sight compasses, they should have the E. on the left side of the dial. In good weather, when the sun shines or where distant features of the landscape are in constant view, there is little chance of error by reading the wrong end of the needle, but there are many conditions under which the compass alone must be the guide.

### VARIATION.

It will be seen by the map (fig. 3) that only along one line in the United States, the so-called "line of no variation," does the needle point due north. This line is not stationary, but has a slow movement westward. At all other points in the United States the north end of the needle is deflected toward the "line of no variation." In the North Atlantic States the variation of the north end of the needle is to the west, and a surveyor at Augusta, Me., would enter in his field notes "variation  $16^{\circ}$  west." At Portland, Oreg., the entry would be "variation  $21\frac{1}{2}^{\circ}$  east." The maximum annual change of variation in the United States is only about 5 minutes. On the Pacific coast it is only 1 minute.

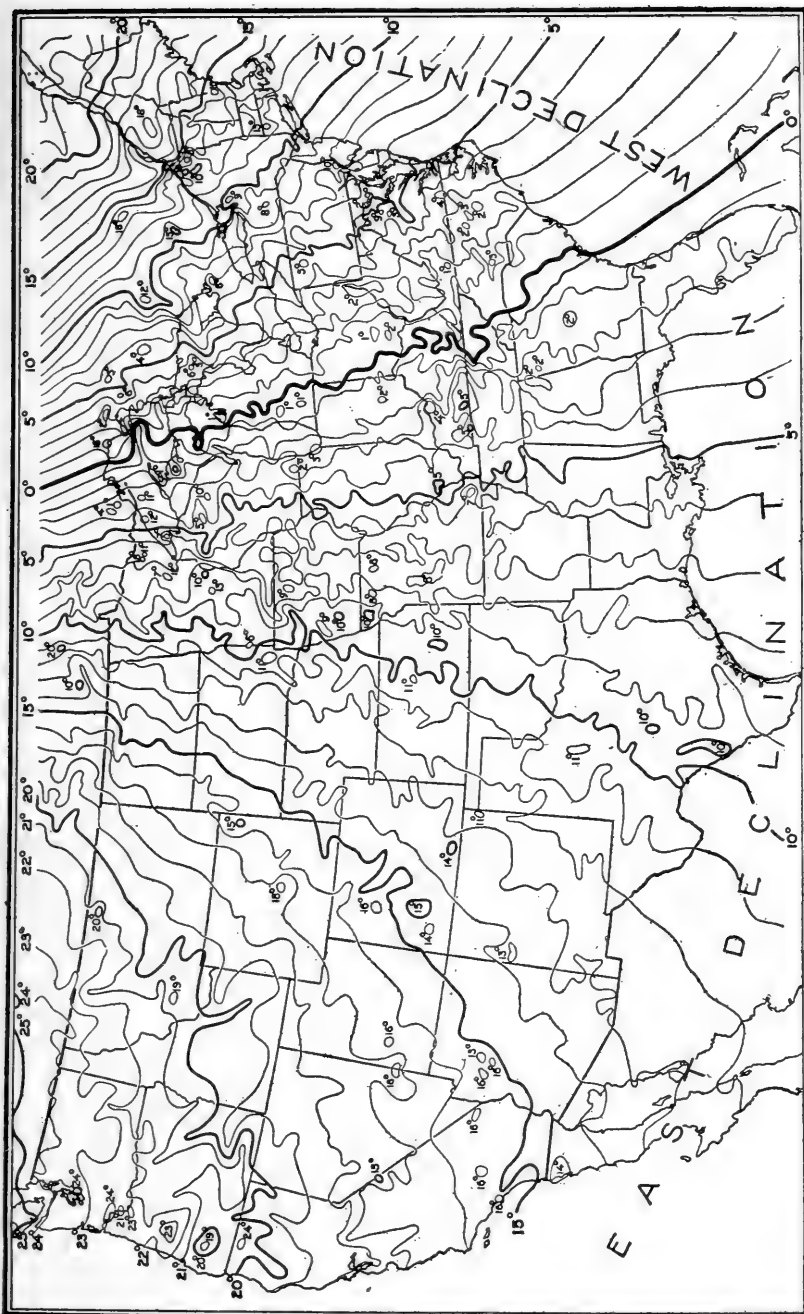


FIG. 3.—Lines of equal magnetic variation in the United States. West of the heavy line the variation is east of true north. East of the heavy line the variation is west of true north.

If a survey is to be made in a region which has not been subdivided by Government land surveys or where the variation of the needle is not known, then the surveyor must do one of three things.

He should if possible find the variation by observing the Pole Star, of which approximate bearings are given (Table 1) at 9 p. m. during the year; or he may obtain the true meridian by observing the sun at apparent noon. If neither can be done, a variation may be assumed after examination of figure 3, and this assumed variation should be entered in the field notes and shown on the map, with the date when the map is prepared.

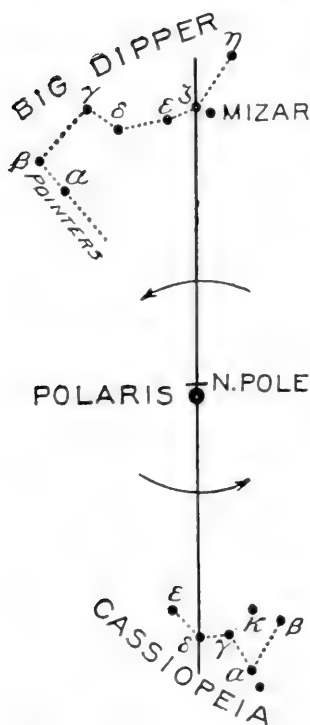


FIG. 4.—Position of the Big Dipper and Cassiopeia when Polaris is due north. If the figure is held upside down it shows the reverse position in which Polaris is also due north.

#### OBSERVING POLARIS.

The Pole Star is not exactly above the North Pole of the earth, but its bearing is due north twice a day, and an observation of it at one of these times will give a true meridian. Mizar, a double star in the bend of the

handle of the Big Dipper is either above or below the Pole Star at these times. The same is true of the star  $\delta$  (Delta) in the constellation Cassiopeia. (See fig. 4.) At all other hours the Pole Star has a bearing either



east or west of true north. It is most convenient to take a sight on Polaris at 9 p. m., and for this reason the accompanying table was prepared. The sight having been taken, it will be easy to turn the compass to true north and ascertain the variation.



## OBTAINING A TRUE MERIDIAN BY OBSERVING THE SUN AT APPARENT NOON.

In addition to the instructions given on pages 16 to 19, there is a method of obtaining a true meridian by observing the sun with a sight compass at the exact time it is due south. The time of this southing is called apparent noon and changes from day to day. It is not the same as local mean noon, nor standard time noon. It is best to set your watch for local mean time, since you can then observe a southing at the time given in Table 2. If your watch is set for standard time, it will be necessary to set it ahead or back by adding or subtracting a correction, according as the longitude of your station is either east or west of one of the standard meridians. These are:

Local mean time at—

Longitude  $75^{\circ}$  = Eastern standard time.

Longitude  $90^{\circ}$  = Central standard time.

Longitude  $105^{\circ}$  = Mountain standard time.

Longitude  $120^{\circ}$  = Pacific standard time.

The correction for a degree of longitude is 4 minutes of time; the correction for a minute of longitude is 4 seconds of time. To illustrate: The local mean time in longitude  $108^{\circ}$  will evidently be 12 minutes behind Mountain standard time, or 48 minutes ahead of Pacific standard time. The local mean time in longitude  $114^{\circ} 35'$  will be 21 minutes and 40 seconds ahead of Pacific standard time. The method is:

Pacific standard time is for longitude  $120^{\circ} 00'$

Local mean time is required for longitude  $114^{\circ} 35'$

The difference in longitude is  $5^{\circ} 25'$

Then  $5^{\circ} \quad 25'$

Multiplied by  $4 \quad 4$

Gives 20 m. 100 s., or 21 m. 40 s.

TABLE 2.—*Showing the hour, minute, and second at which the sun will bear exactly south. The watch must be set to local mean time (not standard, nor sidereal, nor sun time).*

FOR THE YEAR 1912, IN THE WESTERN UNITED STATES.

| Day of month. | Jan.            | Feb.            | Mar.            | Apr.            | May.            | June.           | July.           | Aug.            | Sept.           | Oct.            | Nov.            | Dec.            |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> |
| 1.....        | 12 3 23         | 12 13 41        | 12 12 30        | 12 3 54         | 11 57 0         | 11 57 38        | 12 3 38         | 12 6 8          | 11 59 52        | 11 49 37        | 11 43 39        | 11 49 12        |
| 2.....        | 12 3 51         | 12 13 50        | 12 12 17        | 12 3 36         | 11 56 53        | 11 57 47        | 12 3 49         | 12 6 4          | 11 59 33        | 11 49 18        | 11 43 38        | 11 49 35        |
| 3.....        | 12 4 19         | 12 13 57        | 12 12 4         | 12 3 18         | 11 56 46        | 11 57 56        | 12 4 0          | 12 5 59         | 11 59 14        | 11 48 59        | 11 43 38        | 11 49 58        |
| 4.....        | 12 4 47         | 12 14 3         | 12 11 51        | 12 3 1          | 11 56 40        | 11 58 6         | 12 4 11         | 12 5 54         | 11 58 54        | 11 48 51        | 11 43 39        | 11 50 22        |
| 5.....        | 12 5 14         | 12 14 9         | 12 11 38        | 12 2 43         | 11 56 35        | 11 58 17        | 12 4 21         | 12 5 48         | 11 58 34        | 11 48 23        | 11 43 40        | 11 50 47        |
| 6.....        | 12 5 41         | 12 14 14        | 12 11 24        | 12 2 26         | 11 56 30        | 11 58 27        | 12 4 31         | 12 5 42         | 11 58 14        | 11 48 5         | 11 43 43        | 11 51 13        |
| 7.....        | 12 6 7          | 12 14 18        | 12 11 9         | 12 2 8          | 11 56 25        | 11 58 38        | 12 4 41         | 12 5 35         | 11 57 54        | 11 47 48        | 11 43 46        | 11 51 39        |
| 8.....        | 12 6 33         | 12 14 21        | 12 10 54        | 12 1 51         | 11 56 22        | 11 58 50        | 12 4 51         | 12 5 27         | 11 57 34        | 11 47 31        | 11 43 50        | 11 52 5         |
| 9.....        | 12 6 39         | 12 14 23        | 12 10 39        | 12 1 35         | 11 56 19        | 11 59 1         | 12 5 0          | 12 5 19         | 11 57 13        | 11 47 15        | 11 43 55        | 11 52 32        |
| 10.....       | 12 7 24         | 12 14 25        | 12 10 23        | 12 1 18         | 11 56 16        | 11 59 13        | 12 5 9          | 12 5 11         | 11 56 53        | 11 46 59        | 11 44 1         | 11 52 59        |
| 11.....       | 12 7 48         | 12 14 26        | 12 10 7         | 12 1 2          | 11 56 14        | 11 59 25        | 12 5 17         | 12 5 2          | 11 56 32        | 11 46 44        | 11 44 8         | 11 53 27        |
| 12.....       | 12 8 12         | 12 14 26        | 12 9 51         | 12 0 46         | 11 56 13        | 11 59 37        | 12 5 25         | 12 4 52         | 11 56 11        | 11 46 29        | 11 44 15        | 11 53 55        |
| 13.....       | 12 8 35         | 12 14 25        | 12 9 35         | 12 0 31         | 11 56 12        | 11 59 50        | 12 5 32         | 12 4 41         | 11 55 50        | 11 46 15        | 11 44 24        | 11 54 24        |
| 14.....       | 12 8 58         | 12 14 24        | 12 9 18         | 12 0 16         | 11 56 12        | 12 0 2          | 12 5 39         | 12 4 30         | 11 55 29        | 11 46 1         | 11 44 33        | 11 54 53        |
| 15.....       | 12 9 20         | 12 14 22        | 12 9 1          | 12 0 1          | 11 56 12        | 12 0 15         | 12 5 45         | 12 4 19         | 11 55 8         | 11 45 48        | 11 44 43        | 11 55 22        |
| 16.....       | 12 9 42         | 12 14 19        | 12 8 44         | 11 59 46        | 11 56 13        | 12 0 28         | 12 5 51         | 12 4 7          | 11 54 46        | 11 45 35        | 11 44 54        | 11 55 51        |
| 17.....       | 12 10 2         | 12 14 16        | 12 8 27         | 11 59 32        | 11 56 14        | 12 0 41         | 12 5 56         | 12 3 55         | 11 54 25        | 11 45 23        | 11 45 6         | 11 56 20        |
| 18.....       | 12 10 22        | 12 14 11        | 12 8 10         | 11 59 18        | 11 56 16        | 12 0 54         | 12 6 1          | 12 3 42         | 11 54 4         | 11 45 11        | 11 45 31        | 11 57 19        |
| 19.....       | 12 10 42        | 12 14 7         | 12 7 52         | 11 59 5         | 11 56 19        | 12 1 7          | 12 6 6          | 12 3 28         | 11 53 43        | 11 45 0         | 11 45 46        | 11 57 49        |
| 20.....       | 12 11 0         | 12 14 1         | 12 7 34         | 11 58 52        | 11 56 22        | 12 1 20         | 12 6 9          | 12 3 14         | 11 53 22        | 11 44 49        | 11 45 46        | 11 57 49        |
| 21.....       | 12 11 18        | 12 13 55        | 12 7 16         | 11 58 40        | 11 56 26        | 12 1 33         | 12 6 15         | 12 2 59         | 11 53 0         | 11 44 40        | 11 46 1         | 11 58 19        |
| 22.....       | 12 11 35        | 12 13 48        | 12 6 58         | 11 58 28        | 11 56 30        | 12 1 46         | 12 6 15         | 12 2 44         | 11 52 39        | 11 44 31        | 11 46 16        | 11 58 49        |
| 23.....       | 12 11 51        | 12 13 40        | 12 6 39         | 11 58 16        | 11 56 35        | 12 1 59         | 12 6 17         | 12 2 29         | 11 52 18        | 11 44 22        | 11 46 33        | 11 59 19        |
| 24.....       | 12 12 7         | 12 13 32        | 12 6 21         | 11 58 5         | 11 56 40        | 12 2 12         | 12 6 18         | 12 2 13         | 11 51 58        | 11 44 14        | 11 46 50        | 11 59 49        |
| 25.....       | 12 12 22        | 12 13 23        | 12 6 3          | 11 57 54        | 11 56 45        | 12 2 25         | 12 6 19         | 12 1 57         | 11 51 37        | 11 44 7         | 11 47 8         | 12 0 18         |
| 26.....       | 12 12 35        | 12 13 13        | 12 5 45         | 11 57 44        | 11 56 51        | 12 2 37         | 12 6 19         | 12 1 40         | 11 51 16        | 11 44 1         | 11 47 27        | 12 0 48         |
| 27.....       | 12 12 48        | 12 13 3         | 12 5 26         | 11 57 34        | 11 56 58        | 12 2 49         | 12 6 18         | 12 1 23         | 11 50 56        | 11 43 55        | 11 47 46        | 12 1 18         |
| 28.....       | 12 13 1         | 12 12 53        | 12 5 8          | 11 57 25        | 11 57 5         | 12 3 2          | 12 6 18         | 12 1 6          | 11 50 36        | 11 43 50        | 11 48 6         | 12 1 47         |
| 29.....       | 12 13 12        | 12 12 41        | 12 4 49         | 11 57 16        | 11 57 13        | 12 3 14         | 12 6 16         | 12 0 48         | 11 50 16        | 11 43 46        | 11 48 27        | 12 2 16         |
| 30.....       | 12 13 23        | .....           | 12 4 31         | 11 57 8         | 11 57 21        | 12 3 26         | 12 6 14         | 12 0 29         | 11 49 56        | 11 43 43        | 11 48 49        | 12 2 46         |
| 31.....       | 12 13 32        | .....           | 12 4 13         | .....           | 11 57 29        | .....           | 12 6 11         | 12 0 11         | .....           | 11 43 40        | .....           | 12 3 14         |

TABLE 2a.—Showing the hour, minute, and second at which the sun will bear exactly south. The watch must be set to local mean time (not standard, nor sidereal, nor sun time).

FOR THE YEAR 1913 IN THE WESTERN UNITED STATES.

| Day of month. | Jan.            | Feb.            | Mar.            | Apr.            | May.            | June.           | July.           | Aug.            | Sept.           | Oct.            | Nov.            | Dec.            |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> |
| 1.....        | 12 3 43         | 12 13 47        | 12 12 32        | 12 3 58         | 11 57 1         | 11 57 35        | 12 3 34         | 12 6 9          | 11 59 58        | 11 49 43        | 11 43 41        | 11 49 7         |
| 2.....        | 12 4 11         | 12 13 54        | 12 12 39        | 12 3 40         | 11 56 54        | 11 57 44        | 12 3 46         | 12 6 6          | 11 59 39        | 11 49 24        | 11 43 40        | 11 49 30        |
| 3.....        | 12 4 39         | 12 14 1         | 12 12 7         | 12 3 22         | 11 56 47        | 11 57 54        | 12 3 57         | 12 6 1          | 11 59 20        | 11 49 5         | 11 43 39        | 11 49 54        |
| 4.....        | 12 5 7          | 12 14 7         | 12 11 54        | 12 3 4          | 11 56 41        | 11 58 4         | 12 4 8          | 12 5 56         | 11 59 1         | 11 48 47        | 11 43 40        | 11 50 18        |
| 5.....        | 12 5 34         | 12 14 12        | 12 11 41        | 12 2 47         | 11 56 36        | 11 58 14        | 12 4 19         | 12 5 51         | 11 58 41        | 11 48 29        | 11 43 41        | 11 50 42        |
| 6.....        | 12 6 1          | 12 14 16        | 12 11 27        | 12 2 30         | 11 56 31        | 11 58 25        | 12 4 29         | 12 5 45         | 11 58 21        | 11 48 11        | 11 43 43        | 11 51 7         |
| 7.....        | 12 6 27         | 12 14 20        | 12 11 13        | 12 2 16         | 11 56 27        | 11 58 36        | 12 4 39         | 12 5 38         | 11 58 1         | 11 47 54        | 11 43 46        | 11 51 33        |
| 8.....        | 12 6 53         | 12 14 23        | 12 11 0         | 12 1 56         | 11 56 23        | 11 58 47        | 12 4 49         | 12 5 30         | 11 57 41        | 11 47 37        | 11 43 50        | 11 52 0         |
| 9.....        | 12 7 18         | 12 14 25        | 12 10 43        | 12 1 39         | 11 56 20        | 11 58 59        | 12 4 58         | 12 5 22         | 11 57 20        | 11 47 19        | 11 43 55        | 11 52 26        |
| 10.....       | 12 7 42         | 12 14 26        | 12 10 28        | 12 1 22         | 11 56 17        | 11 59 11        | 12 5 7          | 12 5 14         | 11 56 59        | 11 47 5         | 11 44 1         | 11 52 53        |
| 11.....       | 12 8 6          | 12 14 26        | 12 10 12        | 12 1 6          | 11 56 15        | 11 59 23        | 12 5 15         | 12 5 5          | 11 56 38        | 11 46 49        | 11 44 7         | 11 53 21        |
| 12.....       | 12 8 30         | 12 14 26        | 12 9 56         | 12 0 50         | 11 56 13        | 11 59 35        | 12 5 23         | 12 4 45         | 11 56 17        | 11 46 34        | 11 44 14        | 11 53 49        |
| 13.....       | 12 8 53         | 12 14 25        | 12 9 40         | 12 0 35         | 11 56 12        | 11 59 47        | 12 5 30         | 12 4 45         | 11 55 56        | 11 46 19        | 11 44 22        | 11 54 17        |
| 14.....       | 12 9 15         | 12 14 23        | 12 9 23         | 12 0 20         | 11 56 12        | 12 0 12         | 12 5 37         | 12 4 34         | 11 55 35        | 11 46 5         | 11 44 31        | 11 54 45        |
| 15.....       | 12 9 37         | 12 14 20        | 12 9 6          | 12 0 5          | 11 56 12        | 12 0 12         | 12 5 44         | 12 4 22         | 11 55 13        | 11 45 51        | 11 44 41        | 11 55 14        |
| 16.....       | 12 9 57         | 12 14 16        | 12 8 49         | 11 59 50        | 11 56 12        | 12 0 25         | 12 5 50         | 12 4 10         | 11 54 52        | 11 45 38        | 11 44 52        | 11 55 43        |
| 17.....       | 12 10 17        | 12 14 12        | 12 8 32         | 11 59 36        | 11 56 13        | 12 0 38         | 12 5 55         | 12 3 58         | 11 54 31        | 11 45 26        | 11 45 3         | 11 56 12        |
| 18.....       | 12 10 36        | 12 14 7         | 12 8 14         | 11 59 22        | 11 56 15        | 12 0 50         | 12 6 0          | 12 3 45         | 11 54 9         | 11 45 14        | 11 45 28        | 11 57 11        |
| 19.....       | 12 10 55        | 12 14 2         | 12 7 56         | 11 59 8         | 11 56 18        | 12 1 3          | 12 6 4          | 12 3 31         | 11 53 48        | 11 44 52        | 11 45 42        | 11 57 41        |
| 20.....       | 12 11 13        | 12 13 56        | 12 7 38         | 11 58 55        | 11 56 21        | 12 1 16         | 12 6 8          | 12 3 17         | 11 53 27        | 11 44 33        | 11 45 57        | 11 58 11        |
| 21.....       | 12 11 30        | 12 13 49        | 12 7 20         | 11 58 42        | 11 56 24        | 12 1 29         | 12 6 11         | 12 3 3          | 11 52 45        | 11 44 16        | 11 46 46        | 11 59 41        |
| 22.....       | 12 11 46        | 12 13 41        | 12 7 2          | 11 58 30        | 11 56 28        | 12 1 55         | 12 6 16         | 12 2 33         | 11 52 24        | 11 44 24        | 11 46 29        | 11 59 11        |
| 23.....       | 12 12 2         | 12 13 33        | 12 6 44         | 11 58 18        | 11 56 32        | 12 2 8          | 12 6 18         | 12 2 17         | 11 52 3         | 11 44 16        | 11 46 46        | 11 59 41        |
| 24.....       | 12 12 17        | 12 13 24        | 12 6 25         | 11 58 7         | 11 56 37        | 12 2 21         | 12 6 19         | 12 2 1          | 11 51 42        | 11 44 9         | 11 47 4         | 12 0 11         |
| 25.....       | 12 12 31        | 12 13 15        | 12 6 6          | 11 57 56        | 11 56 43        | 12 2 33         | 12 6 19         | 12 1 45         | 11 51 22        | 11 44 3         | 11 47 23        | 12 0 41         |
| 26.....       | 12 12 44        | 12 13 5         | 12 5 48         | 11 57 45        | 11 56 55        | 12 2 45         | 12 6 19         | 12 1 28         | 11 51 2         | 11 43 57        | 11 48 2         | 12 1 11         |
| 27.....       | 12 12 57        | 12 12 54        | 12 5 30         | 11 57 35        | 11 57 5         | 12 2 58         | 12 6 18         | 12 1 11         | 11 50 42        | 11 43 52        | 11 48 2         | 12 1 40         |
| 28.....       | 12 13 8         | 12 12 43        | 12 5 12         | 11 57 26        | 11 57 2         | 12 3 11         | 12 6 17         | 12 0 53         | 11 50 22        | 11 43 48        | 11 48 23        | 12 2 10         |
| 29.....       | 12 13 19        | .....           | 12 4 53         | 11 57 17        | 11 57 10        | 12 3 11         | 12 6 15         | 12 0 35         | 11 50 2         | 11 43 45        | 11 48 45        | 12 2 39         |
| 30.....       | 12 13 29        | .....           | 12 4 34         | 11 57 9         | 11 57 18        | 12 3 23         | 12 6 12         | 12 0 17         | .....           | 11 43 42        | .....           | 12 3 8          |
| 31.....       | 12 13 38        | .....           | 12 4 16         | .....           | 11 57 26        | .....           | 12 6 12         | .....           | .....           | .....           | .....           | .....           |

(Insert these tables in the "Instructions for Making Forest Surveys and Maps," 1912, page 22.)

TABLE 2b.—*Showing the hour, minute, and second at which the sun will bear exactly south. The watch must be set to local mean time (not standard, nor sidereal, nor sun time).*

FOR THE YEAR 1914 IN THE WESTERN UNITED STATES.

| Day of month. | Jan.            | Feb.            | Mar.            | Apr.            | May.            | June.           | July.           | Aug.            | Sept.           | Oct.            | Nov.            | Dec.            |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> | <i>H. m. s.</i> |
| 1.....        | 12 3 37         | 12 13 45        | 12 12 35        | 12 4 3          | 11 57 4         | 11 57 34        | 12 3 32         | 12 6 11         | 12 0 3          | 11 49 48        | 11 43 41        | 11 49 1         |
| 2.....        | 12 4 5          | 12 13 53        | 12 12 23        | 12 3 45         | 11 56 56        | 11 57 43        | 12 3 44         | 12 6 7          | 11 59 44        | 11 49 29        | 11 43 39        | 11 49 24        |
| 3.....        | 12 4 33         | 12 14 0         | 12 12 10        | 12 3 27         | 11 56 49        | 11 57 52        | 12 3 56         | 12 6 3          | 11 59 25        | 11 49 10        | 11 43 39        | 11 49 47        |
| 4.....        | 12 5 1          | 12 14 6         | 12 11 57        | 12 3 9          | 11 56 43        | 11 58 2         | 12 4 6          | 12 5 58         | 11 59 5         | 11 48 51        | 11 43 39        | 11 50 11        |
| 5.....        | 12 5 28         | 12 14 11        | 12 11 44        | 12 2 51         | 11 56 38        | 11 58 12        | 12 4 17         | 12 5 52         | 11 58 45        | 11 48 33        | 11 43 40        | 11 50 35        |
| 6.....        | 12 5 54         | 12 14 15        | 12 11 30        | 12 2 34         | 11 56 33        | 11 58 22        | 12 4 27         | 12 5 46         | 11 58 25        | 11 48 15        | 11 43 42        | 11 51 0         |
| 7.....        | 12 6 20         | 12 14 19        | 12 11 16        | 12 2 17         | 11 56 28        | 11 58 33        | 12 4 37         | 12 5 39         | 11 58 5         | 11 47 57        | 11 43 45        | 11 51 25        |
| 8.....        | 12 6 46         | 12 14 22        | 12 11 1         | 12 2 0          | 11 56 24        | 11 58 44        | 12 4 46         | 12 5 32         | 11 57 45        | 11 47 40        | 11 43 49        | 11 51 51        |
| 9.....        | 12 7 11         | 12 14 24        | 12 10 46        | 12 1 43         | 11 56 20        | 11 58 55        | 12 4 55         | 12 5 24         | 11 57 24        | 11 47 24        | 11 43 53        | 11 52 18        |
| 10.....       | 12 7 36         | 12 14 25        | 12 10 31        | 12 1 26         | 11 56 17        | 11 59 7         | 12 5 4          | 12 5 15         | 11 57 3         | 11 47 8         | 11 43 58        | 11 52 45        |
| 11.....       | 12 8 0          | 12 14 25        | 12 10 15        | 12 1 10         | 11 56 15        | 11 59 19        | 12 5 13         | 12 5 6          | 11 56 42        | 11 46 52        | 11 44 4         | 11 53 12        |
| 12.....       | 12 8 24         | 12 14 25        | 12 9 59         | 12 0 54         | 11 56 13        | 11 59 31        | 12 5 21         | 12 4 57         | 11 56 21        | 11 46 37        | 11 44 11        | 11 53 40        |
| 13.....       | 12 8 47         | 12 14 24        | 12 9 43         | 12 0 38         | 11 56 11        | 11 59 43        | 12 5 28         | 12 4 47         | 11 56 0         | 11 46 22        | 11 44 19        | 11 54 8         |
| 14.....       | 12 9 9          | 12 14 22        | 12 9 26         | 12 0 22         | 11 56 11        | 11 59 56        | 12 5 35         | 12 4 36         | 11 55 39        | 11 46 8         | 11 44 28        | 11 54 37        |
| 15.....       | 12 9 30         | 12 14 19        | 12 9 9          | 12 0 6          | 11 56 11        | 12 0 8          | 12 5 42         | 12 4 25         | 11 55 18        | 11 45 54        | 11 44 38        | 11 55 6         |
| 16.....       | 12 9 51         | 12 14 16        | 12 8 52         | 11 59 52        | 11 56 11        | 12 0 21         | 12 5 48         | 12 4 13         | 11 54 57        | 11 45 41        | 11 44 48        | 11 55 35        |
| 17.....       | 12 10 11        | 12 14 12        | 12 8 35         | 11 59 38        | 11 56 12        | 12 0 34         | 12 5 53         | 12 4 1          | 11 54 36        | 11 45 29        | 11 44 59        | 11 56 4         |
| 18.....       | 12 10 31        | 12 14 7         | 12 8 17         | 11 59 24        | 11 56 14        | 12 0 47         | 12 5 58         | 12 3 48         | 11 54 25        | 11 45 17        | 11 45 11        | 11 56 34        |
| 19.....       | 12 10 50        | 12 14 2         | 12 7 59         | 11 59 11        | 11 56 16        | 12 1 0          | 12 6 3          | 12 3 35         | 11 53 54        | 11 45 6         | 11 45 24        | 11 57 4         |
| 20.....       | 12 11 8         | 12 13 56        | 12 7 41         | 11 58 58        | 11 56 19        | 12 1 13         | 12 6 7          | 12 3 21         | 11 53 33        | 11 44 55        | 11 45 38        | 11 57 34        |
| 21.....       | 12 11 25        | 12 13 50        | 12 7 23         | 11 58 45        | 11 56 23        | 12 1 26         | 12 6 11         | 12 3 7          | 11 53 12        | 11 44 45        | 11 45 53        | 11 58 4         |
| 22.....       | 12 11 42        | 12 13 42        | 12 7 55         | 11 58 33        | 11 56 27        | 12 1 39         | 12 6 14         | 12 2 52         | 11 52 51        | 11 44 36        | 11 46 9         | 11 58 34        |
| 23.....       | 12 11 58        | 12 13 34        | 12 6 47         | 11 58 21        | 11 56 31        | 12 1 52         | 12 6 16         | 12 2 37         | 11 52 30        | 11 44 27        | 11 46 25        | 11 59 4         |
| 24.....       | 12 12 13        | 12 13 26        | 12 6 29         | 11 58 9         | 11 56 36        | 12 2 5          | 12 6 19         | 12 2 22         | 11 52 9         | 11 44 19        | 11 46 42        | 11 59 34        |
| 25.....       | 12 12 27        | 12 13 17        | 12 6 11         | 11 57 58        | 11 56 42        | 12 2 18         | 12 6 19         | 12 2 6          | 11 51 48        | 11 44 12        | 11 47 0         | 12 0 4          |
| 26.....       | 12 12 41        | 12 13 7         | 12 5 52         | 11 57 48        | 11 56 48        | 12 2 31         | 12 6 20         | 12 1 49         | 11 51 27        | 11 44 5         | 11 47 18        | 12 0 33         |
| 27.....       | 12 12 54        | 12 12 57        | 12 5 34         | 11 57 38        | 11 56 54        | 12 2 44         | 12 6 20         | 12 1 32         | 11 51 7         | 11 43 59        | 11 47 37        | 12 1 3          |
| 28.....       | 12 13 6         | 12 12 46        | 12 5 16         | 11 57 29        | 11 57 1         | 12 2 57         | 12 6 19         | 12 1 15         | 11 50 47        | 11 43 54        | 11 47 57        | 12 1 33         |
| 29.....       | 12 13 17        | .....           | 12 4 57         | 11 57 20        | 11 57 9         | 12 3 9          | 12 6 18         | 12 0 58         | 11 50 27        | 11 43 50        | 11 48 18        | 12 2 2          |
| 30.....       | 12 13 27        | .....           | 12 4 39         | 11 57 12        | 11 57 17        | 12 3 21         | 12 6 16         | 12 0 40         | 11 50 7         | 11 43 46        | 11 48 39        | 12 2 31         |
| 31.....       | 12 13 36        | .....           | 12 4 21         | .....           | 11 57 25        | .....           | 12 6 14         | 12 0 22         | .....           | 11 43 43        | .....           | 12 3 0          |

## PLANE TABLE.

For making any map the plane table is the best instrument in use. Instead of taking notes, as in running compass lines, the surveyor plats his work in the field and can thus always see the progress made. Errors and omissions are discovered quickly and rectified.

The paper upon which the map is to be made is fastened to the plane-table board by thumb tacks, and upon it rests the alidade, a straightedge or ruler with folding sights like a compass. From a point on the paper which represents the starting point on the ground over which the table is standing the surveyor draws lines on the paper with the alidade to the various topographic features which are to be mapped. From start to finish of the survey it must at all stations retain the same orientation—that is to say, at every station where the table is set up its sides must be exactly parallel to its position at the original station.

There are several methods, all based upon the same principles. If an isolated block of forest is to be bounded by a survey, the method would be:

Set up at *A* with one side of the table bearing approximately north and south. As *A* is near the southeast corner of the tract, begin to draw at the corresponding place on the paper. With the alidade draw a line from *A* toward *B*. Measure the distance *AB* on the ground and scale the proportionate distance on the paper. Set the table at *B*. With the alidade on the drawn line take a backsight on *A*. The table will then be oriented or parallel to its position when at *A*. Draw a line on the paper from *B* toward *C*. Measure it and

scale on the map. Proceed as before, and the result will be a map which will truly represent the lines on the ground. (See fig. 5.)

In this case the points *C* and *D* were not visible from *A*, but if, instead of being a block of forest, the area were an open meadow, then a second method would be used.

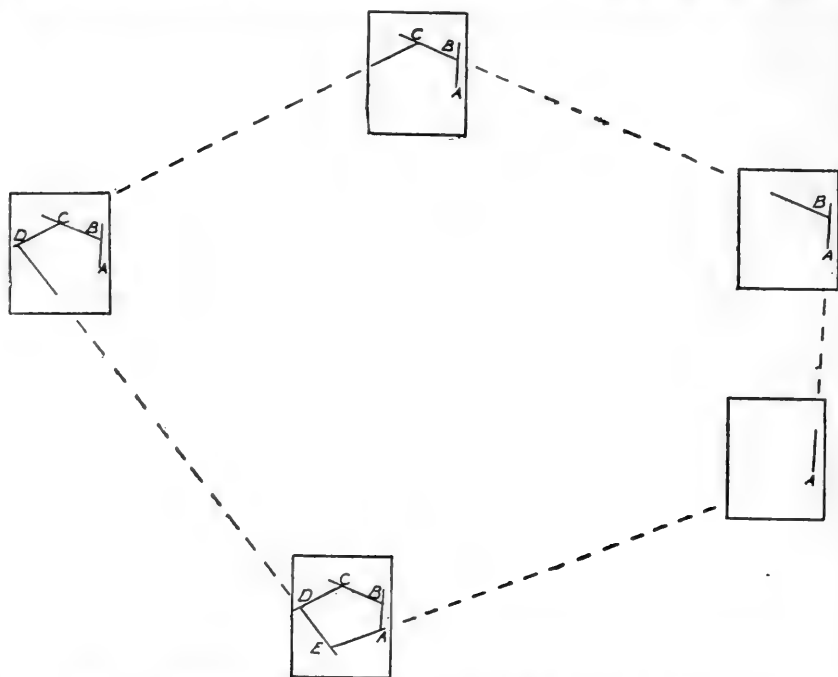


FIG. 5.—Plane-table method in which the table is set up at all the stations.

Set up at *A*. Draw lines to *B*, *C*, *D*, and *E*. Measure *AB*. Set up at *B*. Orient on *A*. Draw lines to *C*, *D*, and *E*. The intersections of the line will give the other three points. The line *AB* is a base line. (See fig. 6.)

The third method is an extension of the second and involves some near-by points which can not be located



from the base line. From *A* and *B* the points *C*, *D*, *E*, and *F* are intersected, and one sight is taken on *G*, which is obviously too nearly in line with the base line to be accurately intersected. Subsequently the table is set up at *C* and oriented by taking sights on *A*, *B*, *D*, *E*, and *F*. It is then easy to intersect *G*, and also get

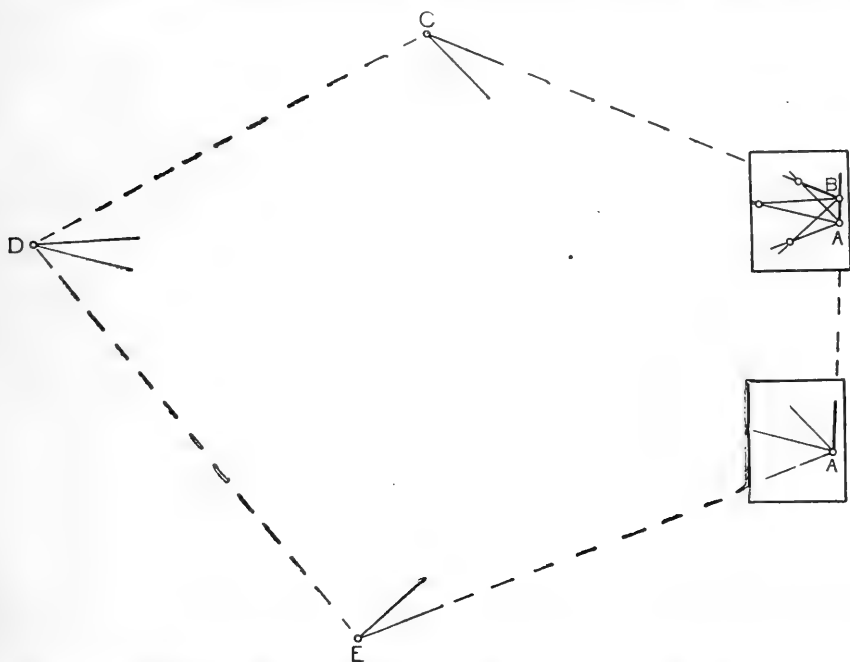


FIG. 6.—Plane-table method in which the table is set up at two stations and the remaining three are located by intersections.

a sight on *H*, which was not visible before. *H* may be intersected from *G*. (See fig. 7.)

A fourth method is employed when the table must be set up at an unknown point from which three or more known points are visible. This is the "three-point problem," in which the suveyor "picks up" his

location. Suppose that  $C$ ,  $D$ , and  $E$  were located by the third method and are high and well-defined peaks. They form a triangle which can be accurately platted on the paper, and the best plan is to prick in the points with a fine needle. The surveyor will then proceed

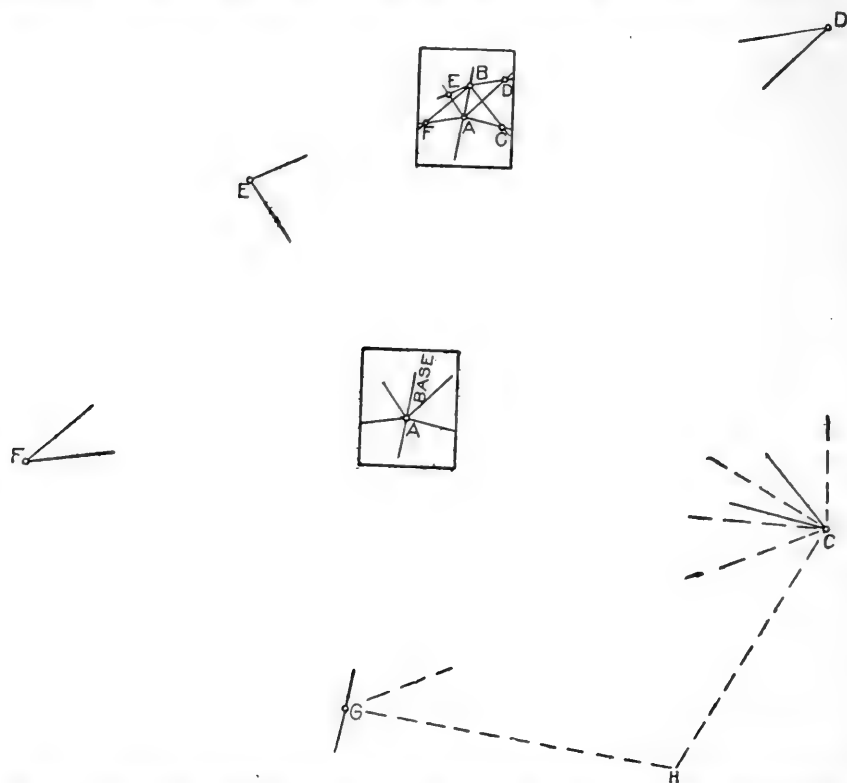


FIG. 7.—Plane-table method of locating points on both sides of a base line which are to be occupied later and the survey extended.

by setting up the table at the point which is to be located and from which he can see the three peaks. Orient approximately by compass. With the alidade draw lines from each peak toward the point of set-up. If the three lines intersect, the desired point is located,

except as noted below. If the lines do not intersect, the orientation may be changed until they do, but an easier plan is to fasten a piece of tracing cloth on the table and assume a point from which the lines may be drawn toward the peaks. The tracing may then be shifted over the paper to find a position at which the lines will

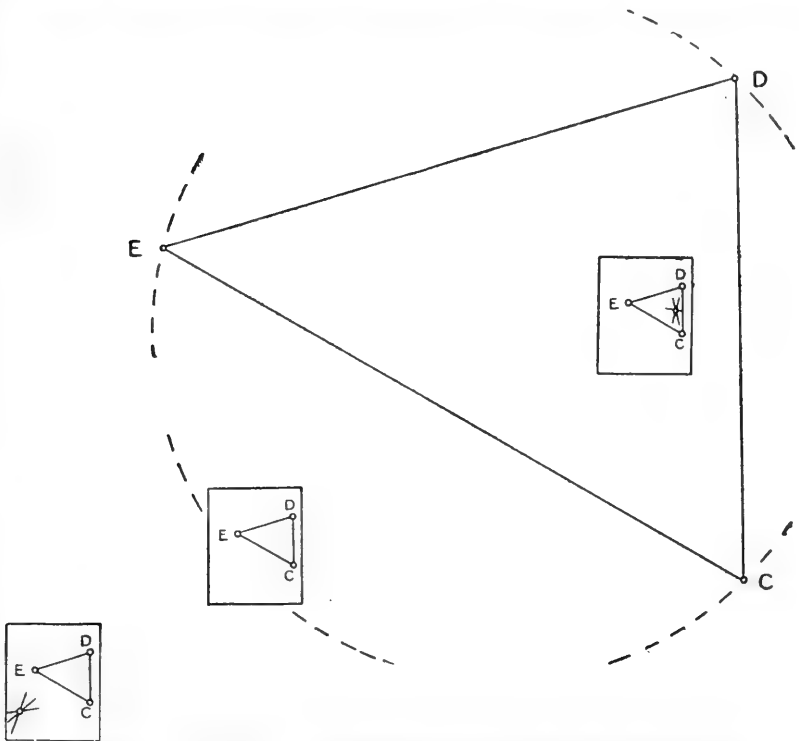


FIG. 8.—Plane-table method of finding location from three points.

exactly cover the three needle holes on the paper. This method is reliable when the desired location is within the triangle, but it is useless when the table is set up on or near a circle which would pass through the three peaks. For this reason four or more points should be used if possible. (See fig. 8.)

With the thumb pressing the release, the sight is taken on the object and the height is read at the same time; or the thumb may be lifted, and the pendulum thus being clamped, the height of the tree may be read through the window.

If the observer stands only 50 feet from the tree the reading must be divided by 2. If he stands 200 feet away it must be multiplied by 2, and proportionately for other distances.

The reading gives the height above the level of the eye. Allowance must be made if the observer's eye is above or below the stump height of the tree.

The notebook and pencil are held in the right hand while an observation is being taken, and the notebook is passed to the left hand when the observation is entered. The hypsometer being on the back of the fingers allows free play for the thumb, palm, and ends of the fingers of the left hand to hold the notebook. In moving from station to station the right hand is then free to assist in getting through the brush or in crossing logs.

The circular pendulum is graduated to tangents. Therefore it may be used to determine the per cent of grade of a road or trail. For this purpose sights may be taken downhill as well as uphill. No conversion of figures is necessary. If the reading is 10 the grade is 10 per cent. It will not hereafter be necessary to use pocket levels for this class of work; since the hypsometer-grademeter answers every purpose.

## DETAILS OF SURVEYING.

## MEASUREMENTS.

The most frequent source of error in pacing, chaining, or steel taping is in counting the tallies—assuming that the mechanical part of the work is well done. The memory should not be trusted. The only safe plan is to enter each tally in the field notes as soon as that tally is completed and the pins or stakes have been counted by both chainmen and before the next tally is begun. When timber is being estimated along the survey line this error is not likely to occur, as the numbers on the timber sheets are a check upon the work.

If a pair of amateur chainmen went over some open level country and reported a distance of 174.62 chains, an error, if one existed, would probably be found in the “tens” or tallies, and a resurvey would give 164.62 or 184.62 chains. The standard chain has a length of 66 feet. If any other unit of linear measure is used, it must be made clear in the notes.

For some classes of work steel tapes or “band chains” are preferable, because, being lighter, they can be longer and stretched straighter than chains.

## CONCERNING ACCURACY.

The field work of the Forest Service extends over millions of acres of wild, very rough, and frequently almost inaccessible lands. In the surveying and mapping of such lands, it should be understood that the term “accuracy” does not call for the degree of precision which would be applied to city lots having a value of

\$1,000 per square foot. The surveys of the Forest Service call for *practical accuracy*, rather than technical correctness or precision.

Figure 10 shows the changing areas in the survey of a square mile in which there is a compass error of one-fourth degree. When measurements close, but not at right angles, the result is a diamond, and the loss in area is about 0.02 of an acre, representing a value of only 5 or 10 cents. In a converging section the loss may be 2.80

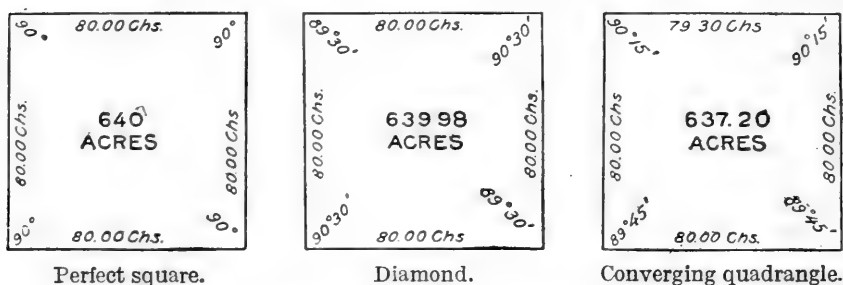


FIG. 10.—Areas of a section containing a compass error of 0.25 degree.

acres, but in either instance such a survey is considered to inclose a conventional section of 640 acres, and this will also be the case if there is an excess acreage to the same extent. To survey a perfect square would be very expensive and not justifiable in view of the trifling values involved.

### TRAVERSE.

When a survey is run along a road or stream, or follows the crest of a divide, the line "meanders" and consists of a number of short courses and distances. The courses are read from the north end of the needle and platted on the map with a protractor. Whenever

the actual change in latitude or departure (longitude) is desired, it may be computed with the traverse table.

In platting with the protractor care should be used that all the angles are set off from the same meridian, otherwise the errors will accumulate. The angles of all courses in surveying are measured from the north and south cardinals toward the east or west, and they should be platted the same. The figures on some protractors are misleading in this respect.

TABLE 3.—*Traverse.*

| Course. | Dist. 1. |        | Dist. 2. |        | Dist. 3. |        | Dist. 4. |        | Dist. 5. |        |         |
|---------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|---------|
|         | Lat.     | Dep.   | Lat.     | Dep.   | Lat.     | Dep.   | Lat.     | Dep.   | Lat.     | Dep.   |         |
| 0 15    | 1.0000   | 0.0044 | 2.0000   | 0.0087 | 3.0000   | 0.0131 | 4.0000   | 0.0175 | 5.0000   | 0.0218 | 89 45   |
| 30      | 0000     | 0087   | 1.9999   | 0.0175 | 2.9999   | 0.0262 | 3.9998   | 0.0349 | 4.9998   | 0.0436 | 30      |
| 45      | 0.9999   | 0.131  | 9998     | 0.262  | 9997     | 0.393  | 9997     | 0.524  | 9996     | 0.654  | 15      |
| 1 0     | 9998     | 0.175  | 9997     | 0.349  | 9995     | 0.524  | 9994     | 0.698  | 9992     | 0.873  | 89 0    |
| 15      | 9998     | 0.218  | 9995     | 0.436  | 9993     | 0.654  | 9990     | 0.873  | 9988     | 1.091  | 45      |
| 30      | 9997     | 0.262  | 9993     | 0.524  | 9990     | 0.785  | 9986     | 1.047  | 9983     | 1.309  | 30      |
| 45      | 9995     | 0.305  | 9991     | 0.611  | 9986     | 0.916  | 9981     | 1.222  | 9977     | 1.527  | 15      |
| 2 0     | 9994     | 0.349  | 9988     | 0.698  | 9982     | 1.047  | 9976     | 1.396  | 9970     | 1.745  | 88 0    |
| 15      | 9992     | 0.393  | 9985     | 0.785  | 9977     | 1.178  | 9969     | 1.570  | 9961     | 1.963  | 45      |
| 30      | 9990     | 0.436  | 9981     | 0.872  | 9971     | 1.309  | 9962     | 1.745  | 9952     | 2.181  | 30      |
| 45      | 0.9988   | 0.480  | 1.9977   | 0.960  | 2.9965   | 0.1439 | 3.9954   | 0.1919 | 4.9942   | 0.2399 | 15      |
| 3 0     | 9986     | 0.523  | 9973     | 1.047  | 9959     | 1.570  | 9945     | 2.093  | 9931     | 2.617  | 87 0    |
| 15      | 9984     | 0.567  | 9968     | 1.134  | 9952     | 1.701  | 9936     | 2.268  | 9920     | 2.835  | 45      |
| 30      | 9981     | 0.610  | 9963     | 1.221  | 9944     | 1.831  | 9925     | 2.412  | 9907     | 3.052  | 30      |
| 45      | 9979     | 0.654  | 9957     | 1.308  | 9936     | 1.962  | 9914     | 2.616  | 9893     | 3.270  | 15      |
| 4 0     | 9976     | 0.698  | 9951     | 1.395  | 9927     | 2.093  | 9903     | 2.790  | 9878     | 3.488  | 86 0    |
| 15      | 9973     | 0.741  | 9945     | 1.482  | 9918     | 2.223  | 9890     | 2.964  | 9863     | 3.705  | 45      |
| 30      | 9969     | 0.785  | 9938     | 1.569  | 9908     | 2.354  | 9877     | 3.138  | 9846     | 3.923  | 30      |
| 45      | 9966     | 0.828  | 9931     | 1.656  | 9897     | 2.484  | 9863     | 3.312  | 9828     | 4.140  | 15      |
| 5 0     | 9962     | 0.872  | 9924     | 1.743  | 9886     | 2.615  | 9848     | 3.486  | 9819     | 4.358  | 85 0    |
| 15      | 0.9958   | 0.915  | 1.9916   | 0.1830 | 2.9874   | 0.2745 | 3.9822   | 0.3660 | 4.9790   | 0.4575 | 45      |
| 30      | 9954     | 0.958  | 9908     | 1.917  | 9862     | 2.875  | 9816     | 3.834  | 9770     | 4.792  | 30      |
| 45      | 9950     | 1.002  | 9899     | 2.004  | 9849     | 3.006  | 9799     | 4.008  | 9748     | 5.009  | 15      |
| 6 0     | 9945     | 1.045  | 9890     | 2.091  | 9836     | 3.136  | 9781     | 4.181  | 9726     | 5.226  | 84 0    |
| 15      | 9941     | 1.089  | 9881     | 2.177  | 9822     | 3.266  | 9762     | 4.355  | 9703     | 5.443  | 45      |
| 30      | 9936     | 1.132  | 9871     | 2.264  | 9807     | 3.396  | 9743     | 4.528  | 9679     | 5.660  | 30      |
| 45      | 9931     | 1.175  | 9861     | 2.351  | 9792     | 3.526  | 9723     | 4.701  | 9653     | 5.877  | 15      |
| 7 0     | 9925     | 1.219  | 9851     | 2.437  | 9776     | 3.656  | 9702     | 4.875  | 9627     | 6.093  | 83 0    |
| 15      | 9920     | 1.262  | 9840     | 2.524  | 9760     | 3.786  | 9680     | 5.048  | 9600     | 6.310  | 45      |
| 30      | 9914     | 1.305  | 9829     | 2.611  | 9743     | 3.916  | 9658     | 5.221  | 9572     | 6.526  | 30      |
| 45      | 0.9909   | 0.1349 | 1.9817   | 0.2697 | 2.9726   | 0.4046 | 3.9635   | 0.5394 | 4.9543   | 0.6743 | 15      |
| 8 0     | 9903     | 1.392  | 9805     | 2.783  | 9708     | 4.175  | 9611     | 5.567  | 9513     | 6.959  | 82 0    |
| 15      | 9897     | 1.435  | 9793     | 2.870  | 9690     | 4.305  | 9586     | 5.740  | 9483     | 7.175  | 45      |
| 30      | 9890     | 1.478  | 9780     | 2.956  | 9670     | 4.434  | 9561     | 5.912  | 9451     | 7.390  | 30      |
| 45      | 9884     | 1.521  | 9767     | 3.042  | 9651     | 4.564  | 9534     | 6.085  | 9418     | 7.606  | 15      |
| 9 0     | 9877     | 1.564  | 9754     | 3.129  | 9631     | 4.693  | 9508     | 6.257  | 9384     | 7.822  | 81 0    |
| 15      | 9870     | 1.607  | 9740     | 3.215  | 9610     | 4.822  | 9480     | 6.430  | 9350     | 8.037  | 45      |
| 30      | 9863     | 1.650  | 9725     | 3.301  | 9589     | 4.951  | 9451     | 6.602  | 9314     | 8.252  | 30      |
| 45      | 9856     | 1.693  | 9711     | 3.387  | 9567     | 5.080  | 9422     | 6.774  | 9278     | 8.467  | 15      |
| 10 0    | 9848     | 1.736  | 9696     | 3.473  | 9544     | 5.209  | 9392     | 6.946  | 9240     | 8.682  | 80 0    |
| 15      | 0.9840   | 0.1779 | 1.9681   | 0.3559 | 2.9521   | 0.5338 | 3.9362   | 0.7118 | 4.9202   | 0.8897 | 45      |
| 30      | 9833     | 1.822  | 9665     | 3.645  | 9498     | 5.467  | 9330     | 7.289  | 9163     | 9.112  | 30      |
| 45      | 9825     | 1.865  | 9649     | 3.730  | 9474     | 5.596  | 9298     | 7.461  | 9123     | 9.326  | 15      |
| 11 0    | 9816     | 1.908  | 9633     | 3.816  | 9449     | 5.724  | 9265     | 7.632  | 9081     | 9.540  | 79 0    |
| 15      | 9808     | 1.951  | 9616     | 3.902  | 9424     | 5.853  | 9231     | 7.804  | 9039     | 9.755  | 45      |
| 30      | 9799     | 1.994  | 9598     | 3.987  | 9398     | 5.981  | 9197     | 7.975  | 8996     | 9.968  | 30      |
| 45      | 9790     | 2.036  | 9581     | 4.073  | 9371     | 6.109  | 9162     | 8.146  | 8952     | 1.0182 | 15      |
| 12 0    | 9781     | 2.079  | 9563     | 4.158  | 9344     | 6.237  | 9126     | 8.316  | 8907     | 0.996  | 78 0    |
| 15      | 9772     | 2.122  | 9545     | 4.244  | 9317     | 6.365  | 9089     | 8.487  | 8862     | 0.609  | 45      |
| 30      | 9763     | 2.164  | 9526     | 4.329  | 9289     | 6.493  | 9052     | 8.658  | 8815     | 0.822  | 30      |
| 45      | 0.9753   | 0.2297 | 1.9507   | 0.4412 | 2.9260   | 0.6621 | 3.9014   | 0.8828 | 4.8767   | 1.1035 | 15      |
| 13 0    | 9744     | 2.250  | 9487     | 4.499  | 9231     | 6.749  | 8975     | 8.998  | 8719     | 1.248  | 77 0    |
| 15      | 9734     | 2.292  | 9468     | 4.584  | 9201     | 6.876  | 8935     | 9.168  | 8669     | 1.460  | 45      |
| 30      | 9724     | 2.334  | 9447     | 4.669  | 9171     | 7.003  | 8895     | 9.338  | 8618     | 1.672  | 30      |
| 45      | 9713     | 2.377  | 9427     | 4.754  | 9140     | 7.131  | 8854     | 9.507  | 8567     | 1.884  | 15      |
| 14 0    | 9703     | 2.419  | 9406     | 4.838  | 9109     | 7.258  | 8812     | 9.677  | 8515     | 2.096  | 76 0    |
| 15      | 9692     | 2.462  | 9385     | 4.923  | 9077     | 7.385  | 8769     | 9.846  | 8462     | 2.308  | 45      |
| 30      | 9681     | 2.504  | 9363     | 5.008  | 9044     | 7.511  | 8726     | 1.0015 | 8407     | 2.519  | 30      |
| 45      | 9670     | 2.546  | 9341     | 5.092  | 9011     | 7.638  | 8682     | 0.184  | 8352     | 2.730  | 15      |
| 15 0    | 9659     | 2.588  | 9319     | 5.176  | 8978     | 7.765  | 8637     | 0.353  | 8296     | 2.941  | 75 0    |
|         | Dep.     | Lat.   | Dep.     | Lat.   | Dep.     | Lat.   | Dep.     | Lat.   | Dep.     | Lat.   | Course. |
|         | Dist. 1. |        | Dist. 2. |        | Dist. 3. |        | Dist. 4. |        | Dist. 5. |        |         |





TABLE 3.—*Traverse*—Continued.

| Course. | Dist. 1. |        | Dist. 2. |        | Dist. 3. |        | Dist. 4. |        | Dist. 5. |        | Course. |
|---------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|---------|
|         | Lat.     | Dep.   | Lat.     | Dep.   | Lat.     | Dep.   | Lat.     | Dep.   | Lat.     | Dep.   |         |
| 30 15   | 0.8638   | 0.5038 | 1.7277   | 1.0075 | 2.5915   | 1.5113 | 3.4553   | 2.0151 | 4.3192   | 2.5189 | 59 45   |
| 30      | 8616     | 5075   | 7233     | 0151   | 5849     | 5226   | 4465     | 0302   | 3081     | 5377   | 30      |
| 45      | 8594     | 5113   | 7188     | 0226   | 5782     | 5339   | 4376     | 0452   | 2970     | 5565   | 15      |
| 31 0    | 8572     | 5150   | 7142     | 0301   | 5715     | 5451   | 4287     | 0602   | 2858     | 5752   | 59 0    |
| 15      | 8549     | 5188   | 7098     | 0375   | 5647     | 5563   | 4196     | 0751   | 2746     | 5939   | 45      |
| 30      | 8526     | 5225   | 7053     | 0450   | 5579     | 5675   | 4106     | 0900   | 2632     | 6125   | 30      |
| 45      | 8504     | 5262   | 7007     | 0524   | 5511     | 5786   | 4014     | 1049   | 2518     | 6311   | 15      |
| 32 0    | 8480     | 5299   | 6961     | 0598   | 5441     | 5898   | 3922     | 1197   | 2402     | 6496   | 58 0    |
| 15      | 8457     | 5336   | 6915     | 0672   | 5372     | 6008   | 3829     | 1345   | 2286     | 6681   | 45      |
| 30      | 8434     | 5373   | 6868     | 0746   | 5302     | 6119   | 3736     | 1492   | 2170     | 6865   | 30      |
| 45      | 0.8410   | 0.5410 | 1.6821   | 1.0819 | 2.5231   | 1.6229 | 3.3642   | 2.1639 | 4.2052   | 2.7049 | 15      |
| 33 0    | 8387     | 5446   | 6773     | 0893   | 5160     | 6339   | 3547     | 1786   | 1934     | 7232   | 57 0    |
| 15      | 8363     | 5483   | 6726     | 0966   | 5089     | 6449   | 3451     | 1932   | 1814     | 7415   | 45      |
| 30      | 8339     | 5519   | 6678     | 1039   | 5017     | 6558   | 3355     | 2077   | 1694     | 7597   | 30      |
| 45      | 8315     | 5556   | 6629     | 1111   | 4944     | 6667   | 3259     | 2223   | 1573     | 7779   | 15      |
| 34 0    | 8290     | 5592   | 6581     | 1184   | 4871     | 6776   | 3162     | 2368   | 1452     | 7960   | 56 0    |
| 15      | 8266     | 5628   | 6532     | 1256   | 4798     | 6884   | 3064     | 2512   | 1329     | 8140   | 45      |
| 30      | 8241     | 5664   | 6483     | 1328   | 4724     | 6992   | 2965     | 2656   | 1206     | 8320   | 30      |
| 45      | 8216     | 5700   | 6433     | 1400   | 4649     | 7100   | 2866     | 2800   | 1082     | 8500   | 15      |
| 35 0    | 8192     | 5736   | 6383     | 1472   | 4575     | 7207   | 2766     | 2943   | 0958     | 8679   | 55 0    |
| 15      | 0.8166   | 0.5771 | 1.6333   | 1.1543 | 2.4999   | 1.7314 | 3.2666   | 2.3086 | 4.0832   | 2.8857 | 45      |
| 30      | 8141     | 5807   | 6282     | 1614   | 4423     | 7421   | 2565     | 3228   | 0706     | 9035   | 30      |
| 45      | 8116     | 5842   | 6231     | 1685   | 4347     | 7527   | 2463     | 3370   | 0579     | 9212   | 15      |
| 36 0    | 8090     | 5878   | 6180     | 1756   | 4271     | 7634   | 2361     | 3511   | 0451     | 9389   | 54 0    |
| 15      | 8064     | 5913   | 6129     | 1826   | 4193     | 7739   | 2258     | 3652   | 0322     | 9565   | 45      |
| 30      | 8039     | 5948   | 6077     | 1896   | 4116     | 7845   | 2154     | 3793   | 0193     | 9741   | 30      |
| 45      | 8013     | 5983   | 6025     | 1966   | 4038     | 7950   | 2050     | 3933   | 0063     | 9916   | 15      |
| 37 0    | 7986     | 6018   | 5973     | 2036   | 3959     | 8054   | 1945     | 4073   | 3.9932   | 3.0091 | 53 0    |
| 15      | 7960     | 6053   | 5920     | 2106   | 3880     | 8159   | 1840     | 4212   | 9800     | 0365   | 45      |
| 30      | 7934     | 6088   | 5867     | 2175   | 3801     | 8263   | 1734     | 4350   | 9668     | 0438   | 30      |
| 45      | 0.7907   | 0.6122 | 1.5814   | 1.2244 | 2.3721   | 1.8367 | 3.1628   | 2.4489 | 3.9534   | 3.0611 | 15      |
| 38 0    | 7880     | 6157   | 5760     | 2313   | 3640     | 8470   | 1520     | 4626   | 9400     | 0783   | 52 0    |
| 15      | 7853     | 6191   | 5706     | 2382   | 3560     | 8573   | 1413     | 4764   | 9266     | 0955   | 45      |
| 30      | 7826     | 6225   | 5652     | 2450   | 3478     | 8675   | 1304     | 4901   | 9130     | 1126   | 30      |
| 45      | 7799     | 6259   | 5598     | 2518   | 3397     | 8778   | 1195     | 5037   | 8994     | 1296   | 15      |
| 39 0    | 7771     | 6293   | 5543     | 2586   | 3314     | 8880   | 1086     | 5173   | 8857     | 1466   | 51 0    |
| 15      | 7744     | 6327   | 5488     | 2654   | 3232     | 8981   | 0976     | 5308   | 8720     | 1635   | 45      |
| 30      | 7716     | 6361   | 5432     | 2722   | 3149     | 9082   | 0865     | 5443   | 8581     | 1804   | 30      |
| 45      | 7688     | 6394   | 5377     | 2789   | 3065     | 9183   | 0754     | 5578   | 8442     | 1972   | 15      |
| 40 0    | 7660     | 6428   | 5321     | 2856   | 2981     | 9284   | 0642     | 5712   | 8302     | 2139   | 50 0    |
| 15      | 0.7632   | 0.6461 | 1.5265   | 1.2922 | 2.2897   | 1.9384 | 3.0529   | 2.5845 | 3.8162   | 3.2306 | 45      |
| 30      | 7604     | 6494   | 5208     | 2989   | 2812     | 9483   | 0416     | 5978   | 8020     | 2472   | 30      |
| 45      | 7576     | 6528   | 5151     | 3055   | 2727     | 9583   | 0303     | 6110   | 7878     | 2638   | 15      |
| 41 0    | 7547     | 6561   | 5094     | 3121   | 2641     | 9682   | 0188     | 6242   | 7735     | 2803   | 49 0    |
| 15      | 7518     | 6593   | 5037     | 3187   | 2555     | 9780   | 0074     | 6374   | 7592     | 2967   | 45      |
| 30      | 7490     | 6626   | 4979     | 3252   | 2469     | 9879   | 2.9958   | 6505   | 7448     | 3131   | 30      |
| 45      | 7461     | 6659   | 4921     | 3318   | 2382     | 9976   | 9842     | 6635   | 7303     | 3294   | 15      |
| 42 0    | 7431     | 6691   | 4863     | 3383   | 2294     | 2.0074 | 9726     | 6765   | 7157     | 3457   | 48 0    |
| 15      | 7402     | 6724   | 4804     | 3447   | 2207     | 0171   | 9609     | 6895   | 7011     | 3618   | 45      |
| 30      | 7373     | 6756   | 4746     | 3512   | 2118     | 0268   | 9491     | 7024   | 6864     | 3780   | 30      |
| 45      | 0.7343   | 0.6788 | 1.4686   | 1.3576 | 2.2030   | 2.0364 | 2.9373   | 2.7152 | 3.6716   | 3.3940 | 15      |
| 43 0    | 7314     | 6820   | 4627     | 3640   | 1941     | 0460   | 9254     | 7280   | 6568     | 4100   | 47 0    |
| 15      | 7284     | 6852   | 4567     | 3704   | 1851     | 0555   | 9135     | 7407   | 6419     | 4259   | 45      |
| 30      | 7254     | 6884   | 4507     | 3767   | 1761     | 0651   | 9015     | 7534   | 6269     | 4418   | 30      |
| 45      | 7224     | 6915   | 4447     | 3830   | 1671     | 0745   | 8895     | 7661   | 6118     | 4576   | 15      |
| 44 0    | 7193     | 6947   | 4387     | 3893   | 1580     | 0840   | 8774     | 7786   | 5967     | 4733   | 46 0    |
| 15      | 7163     | 6978   | 4326     | 3956   | 1489     | 0934   | 8652     | 7912   | 5815     | 4890   | 45      |
| 30      | 7133     | 7009   | 4265     | 4018   | 1398     | 1027   | 8530     | 8036   | 5663     | 5045   | 30      |
| 45      | 7102     | 7040   | 4204     | 4080   | 1306     | 1120   | 8407     | 8161   | 5509     | 5201   | 15      |
| 45 0    | 7071     | 7071   | 4142     | 4142   | 1213     | 1213   | 8284     | 8284   | 5355     | 5355   | 45 0    |
|         | Dep.     | Lat.   | Dep.     | Lat.   | Dep.     | Lat.   | Dep.     | Lat.   | Dep.     | Lat.   | Course. |
|         | Dist. 1. |        | Dist. 2. |        | Dist. 3. |        | Dist. 4. |        | Dist. 5. |        |         |

TABLE 3.—*Traverse*—Continued.

| Course. | Dist. 6. |        | Dist. 7. |        | Dist. 8. |        | Dist. 9. |        | Dist. 10. |        |         |
|---------|----------|--------|----------|--------|----------|--------|----------|--------|-----------|--------|---------|
|         | Lat.     | Dep.   | Lat.     | Dep.   | Lat.     | Dep.   | Lat.     | Dep.   | Lat.      | Dep.   |         |
| 0 15    | 5.9999   | 0.0262 | 6.9999   | 0.0305 | 7.9999   | 0.0349 | 8.9999   | 0.0393 | 9.9999    | 0.0436 | 89 45   |
| 30      | 9998     | 0524   | 9997     | 0611   | 9997     | 0698   | 9997     | 0785   | 9996      | 0873   | 30      |
| 45      | 9995     | 0785   | 9994     | 0916   | 9993     | 1047   | 9992     | 1178   | 9996      | 1309   | 15      |
| 1 0     | 9991     | 1047   | 9989     | 1222   | 9988     | 1396   | 9986     | 1571   | 9985      | 1745   | 89 0    |
| 15      | 9986     | 1309   | 9983     | 1527   | 9981     | 1745   | 9979     | 1963   | 9976      | 2181   | 45      |
| 30      | 9979     | 1571   | 9976     | 1832   | 9973     | 2094   | 9969     | 2356   | 9966      | 2618   | 30      |
| 45      | 9972     | 1832   | 9967     | 2138   | 9963     | 2443   | 9958     | 2748   | 9953      | 3054   | 15      |
| 2 0     | 9963     | 2094   | 9957     | 2443   | 9951     | 2792   | 9945     | 3141   | 9939      | 3490   | 88 0    |
| 15      | 9954     | 2356   | 9946     | 2748   | 9938     | 3141   | 9931     | 3533   | 9923      | 3926   | 45      |
| 30      | 9943     | 2617   | 9933     | 3053   | 9924     | 3490   | 9914     | 3926   | 9905      | 4362   | 30      |
| 45      | 5.9931   | 0.2879 | 6.9919   | 0.3358 | 7.9908   | 0.3838 | 8.9896   | 0.4318 | 9.9885    | 0.4798 | 15      |
| 3 0     | 9918     | 3140   | 9904     | 3664   | 9890     | 4187   | 9877     | 4710   | 9863      | 5234   | 87 0    |
| 15      | 9904     | 3402   | 9887     | 3968   | 9871     | 4535   | 9855     | 5102   | 9839      | 5669   | 45      |
| 30      | 9888     | 3663   | 9869     | 4273   | 9851     | 4884   | 9832     | 5494   | 9813      | 6105   | 30      |
| 45      | 9872     | 3924   | 9850     | 4578   | 9829     | 5232   | 9807     | 5886   | 9786      | 6540   | 15      |
| 4 0     | 9854     | 4185   | 9829     | 4883   | 9805     | 5581   | 9781     | 6278   | 9756      | 6976   | 86 0    |
| 15      | 9835     | 4447   | 9808     | 5188   | 9780     | 5929   | 9753     | 6670   | 9725      | 7411   | 45      |
| 30      | 9815     | 4708   | 9784     | 5492   | 9753     | 6277   | 9723     | 7061   | 9692      | 7846   | 30      |
| 45      | 9794     | 4968   | 9760     | 5797   | 9725     | 6625   | 9691     | 7453   | 9657      | 8281   | 15      |
| 5 0     | 9772     | 5229   | 9734     | 6101   | 9696     | 6972   | 9658     | 7844   | 9619      | 8716   | 85 0    |
| 15      | 5.9748   | 0.5490 | 6.9706   | 0.6405 | 7.9664   | 0.7320 | 8.9622   | 0.8235 | 9.9580    | 0.9150 | 45      |
| 30      | 9724     | 5751   | 9678     | 6709   | 9632     | 7668   | 9586     | 8626   | 9540      | 9585   | 30      |
| 45      | 9698     | 6011   | 9648     | 7013   | 9597     | 8015   | 9547     | 9017   | 9497      | 1.0019 | 15      |
| 6 0     | 9671     | 6272   | 9617     | 7317   | 9562     | 8362   | 9507     | 9408   | 9452      | 0.453  | 84 0    |
| 15      | 9643     | 6532   | 9584     | 7621   | 9525     | 8709   | 9465     | 9798   | 9406      | 0.887  | 45      |
| 30      | 9614     | 6792   | 9550     | 7924   | 9486     | 9056   | 9421     | 1.0188 | 9357      | 1320   | 30      |
| 45      | 9584     | 7052   | 9515     | 8228   | 9445     | 9403   | 9376     | 0.578  | 9307      | 1754   | 15      |
| 7 0     | 9553     | 7312   | 9478     | 8531   | 9404     | 9750   | 9329     | 0.968  | 9255      | 2187   | 83 0    |
| 15      | 9520     | 7572   | 9440     | 8834   | 9360     | 1.0096 | 9280     | 1358   | 9200      | 2620   | 45      |
| 30      | 9487     | 7832   | 9401     | 9137   | 9316     | 0.442  | 9230     | 1747   | 9144      | 3053   | 30      |
| 45      | 5.9452   | 0.8091 | 6.9361   | 0.9440 | 7.9269   | 1.0788 | 8.9178   | 1.2137 | 9.9087    | 1.3485 | 15      |
| 8 0     | 9416     | 8350   | 9319     | 9742   | 9221     | 1134   | 9124     | 2526   | 9027      | 3917   | 82 0    |
| 15      | 9379     | 8610   | 9276     | 1.0044 | 9172     | 1479   | 9069     | 2914   | 8965      | 4349   | 45      |
| 30      | 9341     | 8869   | 9231     | 0.347  | 9121     | 1825   | 9011     | 3303   | 8902      | 4781   | 30      |
| 45      | 9302     | 9127   | 9185     | 0.649  | 9069     | 2170   | 8953     | 3691   | 8836      | 5212   | 15      |
| 9 0     | 9261     | 9386   | 9138     | 0.950  | 9015     | 2515   | 8892     | 4079   | 8769      | 5643   | 81 0    |
| 15      | 9220     | 9645   | 9090     | 1.252  | 8960     | 2859   | 8830     | 4467   | 8700      | 6074   | 45      |
| 30      | 9177     | 9903   | 9040     | 1.553  | 8903     | 3204   | 8766     | 4854   | 8629      | 6505   | 30      |
| 45      | 9133     | 1.0161 | 8989     | 1.854  | 8844     | 3548   | 8700     | 5241   | 8556      | 6935   | 15      |
| 10 0    | 9088     | 0.419  | 8937     | 2.155  | 8785     | 3892   | 8633     | 5628   | 8481      | 7365   | 80 0    |
| 15      | 5.9042   | 1.0677 | 6.8883   | 1.2456 | 7.8723   | 1.4235 | 8.8564   | 1.6015 | 9.8404    | 1.7794 | 45      |
| 30      | 8995     | 0.934  | 8728     | 2.756  | 8660     | 4579   | 8493     | 6401   | 8325      | 8224   | 30      |
| 45      | 8947     | 1.191  | 8772     | 3.057  | 8596     | 4922   | 8421     | 6787   | 8245      | 8652   | 15      |
| 11 0    | 8898     | 1.449  | 8714     | 3.357  | 8530     | 5265   | 8346     | 7173   | 8163      | 9081   | 79 0    |
| 15      | 8847     | 1.705  | 8655     | 3.656  | 8463     | 5607   | 8271     | 7558   | 8079      | 9509   | 45      |
| 30      | 8795     | 1.962  | 8595     | 3.956  | 8394     | 5949   | 8193     | 7943   | 7992      | 9937   | 30      |
| 45      | 8743     | 2.219  | 8533     | 4.255  | 8324     | 6291   | 8114     | 8328   | 7905      | 2.0364 | 15      |
| 12 0    | 8689     | 2.475  | 8470     | 4.554  | 8252     | 6633   | 8033     | 8712   | 7815      | 0.791  | 78 0    |
| 15      | 8634     | 2.731  | 8406     | 4.852  | 8178     | 6974   | 7951     | 9096   | 7723      | 1.218  | 45      |
| 30      | 8578     | 2.986  | 8341     | 5.151  | 8104     | 7315   | 7867     | 9480   | 7630      | 1.644  | 30      |
| 45      | 5.8521   | 1.3242 | 6.8274   | 1.5449 | 7.8027   | 1.7656 | 8.7781   | 1.9863 | 9.7534    | 2.2070 | 15      |
| 13 0    | 8462     | 3.497  | 8206     | 5.747  | 7950     | 7996   | 7693     | 2.0246 | 7437      | 2.495  | 77 0    |
| 15      | 8403     | 3.752  | 8137     | 6.044  | 7870     | 8336   | 7604     | 0.628  | 7338      | 2.920  | 45      |
| 30      | 8342     | 4.007  | 8066     | 6.341  | 7790     | 8676   | 7513     | 1.010  | 7237      | 3.345  | 30      |
| 45      | 8281     | 4.261  | 7994     | 6.638  | 7707     | 9015   | 7421     | 1.392  | 7134      | 3.769  | 15      |
| 14 0    | 8218     | 4.515  | 7921     | 6.935  | 7624     | 9354   | 7327     | 1.773  | 7030      | 4.192  | 76 0    |
| 15      | 8154     | 4.769  | 7846     | 7.231  | 7538     | 9692   | 7231     | 2.154  | 6923      | 4.615  | 45      |
| 30      | 8089     | 5.023  | 7770     | 7.527  | 7452     | 2.0030 | 7133     | 2.534  | 6815      | 5.038  | 30      |
| 45      | 8023     | 5.276  | 7693     | 7.822  | 7364     | 0.368  | 7034     | 2.914  | 6705      | 5.460  | 15      |
| 15 0    | 7956     | 5.529  | 7615     | 8.117  | 7274     | 0.706  | 6933     | 3.294  | 6593      | 5.882  | 75 0    |
|         | Dep.     | Lat.   | Dep.     | Lat.   | Dep.     | Lat.   | Dep.     | Lat.   | Dep.      | Lat.   | Course. |
|         | Dist. 6. |        | Dist. 7. |        | Dist. 8. |        | Dist. 9. |        | Dist. 10. |        |         |

TABLE 3.—*Traverse*—Continued.

| Course. | Dist. 6. |        | Dist. 7. |        | Dist. 8. |        | Dist. 9. |        | Dist. 10. |        |         |
|---------|----------|--------|----------|--------|----------|--------|----------|--------|-----------|--------|---------|
|         | Lat.     | Dep.   | Lat.     | Dep.   | Lat.     | Dep.   | Lat.     | Dep.   | Lat.      | Dep.   |         |
| 15 15   | 5.7887   | 1.5782 | 6.7535   | 1.8412 | 7.7183   | 2.1042 | 8.6831   | 2.3673 | 9.6479    | 2.6303 | 74 45   |
| 30      | 7818     | 6034   | 7454     | 8707   | 7090     | 1379   | 6727     | 4051   | 6363      | 6724   | 30      |
| 45      | 7747     | 6286   | 7372     | 9001   | 6996     | 1715   | 6621     | 4430   | 6246      | 7144   | 15      |
| 16 0    | 7676     | 6538   | 7288     | 9295   | 6901     | 2051   | 6514     | 4807   | 6126      | 7564   | 74 0    |
| 15      | 7603     | 6790   | 7203     | 9588   | 6804     | 2386   | 6404     | 5185   | 6005      | 7983   | 45      |
| 30      | 7529     | 7041   | 7117     | 9881   | 6706     | 2721   | 6294     | 5561   | 5882      | 8402   | 30      |
| 45      | 7454     | 7292   | 7030     | 2.0174 | 6606     | 3056   | 6181     | 5928   | 5757      | 8820   | 15      |
| 17 0    | 7378     | 7542   | 6941     | 0466   | 6504     | 3390   | 6067     | 6313   | 5630      | 9237   | 73 0    |
| 15      | 7301     | 7792   | 6851     | 0758   | 6402     | 3723   | 5952     | 6689   | 5502      | 9654   | 45      |
| 30      | 7223     | 8042   | 6760     | 1049   | 6297     | 4056   | 5835     | 7064   | 5372      | 3.0071 | 30      |
| 45      | 5.7144   | 1.8292 | 6.6668   | 2.1341 | 7.6192   | 2.4389 | 8.5716   | 2.7438 | 9.5240    | 3.0486 | 15      |
| 18 0    | 7063     | 8541   | 6574     | 1631   | 6085     | 4721   | 5595     | 7812   | 5106      | 0902   | 72 0    |
| 15      | 6982     | 8790   | 6479     | 1921   | 5976     | 5053   | 5473     | 8185   | 4970      | 1316   | 45      |
| 30      | 6899     | 9038   | 6383     | 2211   | 5866     | 5384   | 5349     | 8557   | 4832      | 1730   | 30      |
| 45      | 6816     | 9286   | 6285     | 2501   | 5754     | 5715   | 5224     | 8930   | 4693      | 2144   | 15      |
| 19 0    | 6731     | 9534   | 6186     | 2790   | 5641     | 6045   | 5097     | 9301   | 4552      | 2557   | 71 0    |
| 15      | 6645     | 9781   | 6086     | 3078   | 5527     | 6375   | 4968     | 9672   | 4409      | 2969   | 45      |
| 30      | 6558     | 2.0028 | 5985     | 3366   | 5411     | 6705   | 4838     | 3.0043 | 4264      | 3381   | 30      |
| 45      | 6471     | 0275   | 5882     | 3654   | 5294     | 7033   | 4706     | 0413   | 4118      | 3792   | 15      |
| 20 0    | 6382     | 0521   | 5778     | 3941   | 5175     | 7362   | 4572     | 0782   | 3969      | 4202   | 70 0    |
| 15      | 5.6291   | 2.0767 | 6.5673   | 2.4228 | 7.5055   | 2.7689 | 8.4437   | 3.1151 | 9.3819    | 3.4612 | 45      |
| 30      | 6200     | 1012   | 5567     | 4515   | 4934     | 8017   | 4300     | 1519   | 3667      | 5021   | 30      |
| 45      | 6108     | 1257   | 5459     | 4800   | 4811     | 8343   | 4162     | 1886   | 3514      | 5429   | 15      |
| 21 0    | 6015     | 1502   | 5351     | 5086   | 4686     | 8669   | 4022     | 2253   | 3358      | 5837   | 69 0    |
| 15      | 5920     | 1746   | 5241     | 5371   | 4561     | 8995   | 3881     | 2619   | 3201      | 6244   | 45      |
| 30      | 5825     | 1990   | 5129     | 5655   | 4433     | 9320   | 3738     | 2985   | 3042      | 6650   | 30      |
| 45      | 5729     | 2233   | 5017     | 5939   | 4305     | 9645   | 3593     | 3350   | 2881      | 7056   | 15      |
| 22 0    | 5631     | 2476   | 4903     | 6222   | 4175     | 9969   | 3447     | 3715   | 2718      | 7461   | 68 0    |
| 15      | 5532     | 2719   | 4788     | 6505   | 4043     | 3.0292 | 3299     | 4078   | 2554      | 7855   | 45      |
| 30      | 5433     | 2961   | 4672     | 6788   | 3910     | 0615   | 3149     | 4442   | 2388      | 8268   | 30      |
| 45      | 5.5332   | 2.3203 | 6.4554   | 2.7070 | 7.3776   | 3.0937 | 8.2998   | 3.4804 | 9.2220    | 3.8671 | 15      |
| 23 0    | 5230     | 3414   | 4435     | 7351   | 3640     | 1258   | 2845     | 5166   | 2050      | 9073   | 67 0    |
| 15      | 5127     | 3685   | 4315     | 7632   | 3503     | 1580   | 2691     | 5527   | 1879      | 9474   | 45      |
| 30      | 5024     | 3925   | 4194     | 7912   | 3365     | 1900   | 2535     | 5887   | 1706      | 9875   | 30      |
| 45      | 4919     | 4165   | 4072     | 8192   | 3225     | 2220   | 2378     | 6247   | 1531      | 4.0275 | 15      |
| 24 0    | 4813     | 4404   | 3948     | 8472   | 3084     | 2539   | 2219     | 6606   | 1355      | 0674   | 66 0    |
| 15      | 4706     | 4643   | 3823     | 8750   | 2941     | 2858   | 2059     | 6965   | 1176      | 1072   | 45      |
| 30      | 4598     | 4882   | 3697     | 9029   | 2797     | 3175   | 1897     | 7322   | 0996      | 1469   | 30      |
| 45      | 4489     | 5120   | 3570     | 9306   | 2651     | 3493   | 1733     | 7679   | 0814      | 1866   | 15      |
| 25 0    | 4378     | 5357   | 3442     | 9583   | 2505     | 3809   | 1568     | 8036   | 0631      | 2262   | 65 0    |
| 15      | 5.4267   | 2.5594 | 6.3312   | 2.9800 | 7.2356   | 3.4125 | 8.1401   | 3.8391 | 9.0446    | 4.2657 | 45      |
| 30      | 4155     | 5831   | 3181     | 3.0136 | 2207     | 4441   | 1233     | 8746   | 0259      | 3051   | 30      |
| 45      | 4042     | 6067   | 3049     | 0411   | 2036     | 4756   | 1063     | 9100   | 0070      | 3445   | 15      |
| 26 0    | 3928     | 6302   | 2916     | 0686   | 1904     | 5070   | 0591     | 9453   | 8.9879    | 3837   | 64 0    |
| 15      | 3812     | 6537   | 2781     | 0960   | 1750     | 5383   | 0719     | 9806   | 9687      | 4229   | 45      |
| 30      | 3696     | 6772   | 2645     | 1234   | 1595     | 5696   | 0644     | 4.0158 | 9493      | 4620   | 30      |
| 45      | 3579     | 7006   | 2509     | 1507   | 1438     | 6008   | 0368     | 0509   | 9298      | 5010   | 15      |
| 27 0    | 3460     | 7239   | 2370     | 1779   | 1281     | 6319   | 0191     | 0859   | 9101      | 5399   | 63 0    |
| 15      | 3341     | 7472   | 2231     | 2051   | 1121     | 6630   | 0012     | 1209   | 8902      | 5787   | 45      |
| 30      | 3221     | 7705   | 2091     | 2322   | 0961     | 6940   | 7.9831   | 1557   | 8701      | 6175   | 30      |
| 45      | 5.3099   | 2.7937 | 6.1949   | 3.2593 | 7.0799   | 3.7249 | 7.9649   | 4.1905 | 8.8499    | 4.6561 | 15      |
| 28 0    | 2977     | 8168   | 1806     | 2863   | 0636     | 7558   | 9465     | 2252   | 8295      | 6947   | 62 0    |
| 15      | 2853     | 8399   | 1662     | 3132   | 0471     | 7866   | 9280     | 2599   | 8089      | 7332   | 45      |
| 30      | 2729     | 8630   | 1517     | 3401   | 0305     | 8173   | 9094     | 2944   | 7882      | 7716   | 30      |
| 45      | 2604     | 8859   | 1371     | 3669   | 0138     | 8479   | 8905     | 3289   | 7673      | 8099   | 15      |
| 29 0    | 2477     | 9089   | 1223     | 3937   | 6.9970   | 8785   | 8716     | 3633   | 7462      | 8481   | 61 0    |
| 15      | 2350     | 9317   | 1075     | 4203   | 9800     | 9900   | 8525     | 3976   | 7250      | 8862   | 45      |
| 30      | 2221     | 9545   | 0925     | 4470   | 9628     | 9394   | 8332     | 4318   | 7036      | 9242   | 30      |
| 45      | 2092     | 9773   | 0774     | 4735   | 9456     | 9697   | 8138     | 4659   | 6820      | 9622   | 15      |
| 30 0    | 1962     | 3.0000 | 0622     | 5000   | 9282     | 4.0000 | 7942     | 5000   | 6603      | 5.0000 | 60 0    |
|         | Dep.     | Lat.   | Dep.     | Lat.   | Dep.     | Lat.   | Dep.     | Lat.   | Dep.      | Lat.   | Course. |
|         | Dist. 6. |        | Dist. 7. |        | Dist. 8. |        | Dist. 9. |        | Dist. 10. |        |         |

TABLE 3.—*Traverse*—Continued.

| Course. | Dist. 6. |        | Dist. 7. |        | Dist. 8. |        | Dist. 9. |        | Dist. 10. |        | Course. |
|---------|----------|--------|----------|--------|----------|--------|----------|--------|-----------|--------|---------|
|         | Lat.     | Dep.   | Lat.     | Dep.   | Lat.     | Dep.   | Lat.     | Dep.   | Lat.      | Dep.   |         |
| 30 15   | 5.1830   | 3.0226 | 6.0468   | 3.5264 | 6.9107   | 4.0302 | 7.7745   | 4.5340 | 8.6384    | 5.0377 | 59 45   |
| 30      | 1698     | 0452   | 0314     | 5528   | 8930     | 0603   | 7547     | 5678   | 6163      | 0754   | 30      |
| 45      | 1564     | 0678   | 0158     | 5791   | 8753     | 0903   | 7347     | 6016   | 5941      | 1129   | 15      |
| 31 0    | 1430     | 0902   | 0002     | 6053   | 8573     | 1203   | 7145     | 6353   | 5717      | 1504   | 59 0    |
| 15      | 1295     | 1126   | 5.9844   | 6314   | 8393     | 1502   | 6942     | 6690   | 5491      | 1877   | 45      |
| 30      | 1158     | 1350   | 9685     | 6575   | 8211     | 1800   | 6738     | 7025   | 5264      | 2230   | 30      |
| 45      | 1021     | 1573   | 9525     | 6835   | 8028     | 2097   | 6532     | 7259   | 5035      | 2621   | 15      |
| 32 0    | 0883     | 1795   | 9363     | 7094   | 7844     | 2394   | 6324     | 7693   | 4875      | 2992   | 58 0    |
| 15      | 0744     | 2017   | 9201     | 7353   | 7658     | 2689   | 6116     | 8025   | 4573      | 3361   | 45      |
| 30      | 0603     | 2238   | 9037     | 7611   | 7471     | 2984   | 5905     | 8357   | 4339      | 3730   | 30      |
| 45      | 5.0462   | 3.2458 | 5.8873   | 3.7868 | 6.7283   | 4.3278 | 7.5694   | 4.8688 | 8.4104    | 5.4097 | 15      |
| 33 0    | 0320     | 2678   | 8707     | 8125   | 7094     | 3571   | 5480     | 9018   | 3867      | 4464   | 57 0    |
| 15      | 0177     | 2898   | 8540     | 8381   | 6903     | 3862   | 5266     | 9346   | 3629      | 4829   | 45      |
| 30      | 0033     | 3116   | 8372     | 8636   | 6711     | 4155   | 5050     | 9674   | 3389      | 5194   | 30      |
| 45      | 4.9888   | 3334   | 8203     | 8890   | 6518     | 4446   | 4832     | 5.0001 | 3147      | 5557   | 15      |
| 34 0    | 9742     | 3552   | 8033     | 9144   | 6323     | 4735   | 4613     | 0327   | 2904      | 5919   | 56 0    |
| 15      | 9595     | 3768   | 7861     | 9396   | 6127     | 5024   | 4393     | 0652   | 2659      | 6280   | 45      |
| 30      | 9448     | 3984   | 7689     | 9648   | 5930     | 5312   | 4171     | 0977   | 2413      | 6641   | 30      |
| 45      | 9299     | 4200   | 7515     | 9900   | 5732     | 5600   | 3948     | 1300   | 2165      | 7000   | 15      |
| 35 0    | 9149     | 4415   | 7341     | 4.0150 | 5532     | 5886   | 3724     | 1622   | 1915      | 7358   | 55 0    |
| 15      | 4.8998   | 3.4629 | 5.7165   | 4.0400 | 6.5331   | 4.6172 | 7.3498   | 5.1943 | 8.1664    | 5.7715 | 45      |
| 30      | 8847     | 4842   | 6988     | 0649   | 5129     | 6456   | 3270     | 2203   | 1412      | 8070   | 30      |
| 45      | 8694     | 5055   | 6810     | 0897   | 4926     | 6740   | 3042     | 2582   | 1157      | 8425   | 15      |
| 36 0    | 8541     | 5267   | 6631     | 1145   | 4721     | 7023   | 2812     | 2901   | 0902      | 8779   | 54 0    |
| 15      | 8387     | 5479   | 6451     | 1392   | 4516     | 7305   | 2580     | 3218   | 0644      | 9131   | 45      |
| 30      | 8231     | 5689   | 6270     | 1638   | 4309     | 7586   | 2347     | 3534   | 0386      | 9482   | 30      |
| 45      | 8075     | 5899   | 6088     | 1883   | 4100     | 7860   | 2113     | 3849   | 0125      | 9832   | 15      |
| 37 0    | 7918     | 6109   | 5904     | 2127   | 3891     | 8145   | 1877     | 4163   | 7.9864    | 6.0182 | 53 0    |
| 15      | 7760     | 6318   | 5720     | 2371   | 3680     | 8424   | 1640     | 4476   | 9600      | 0529   | 45      |
| 30      | 7601     | 6526   | 5535     | 2613   | 3468     | 8701   | 1402     | 4789   | 9335      | 0876   | 30      |
| 45      | 4.7441   | 3.6733 | 5.5348   | 4.2855 | 6.3255   | 4.8977 | 7.1162   | 5.1100 | 7.9069    | 6.1222 | 15      |
| 38 0    | 7281     | 6940   | 5161     | 3096   | 3041     | 9253   | 0921     | 5410   | 8801      | 1566   | 52 0    |
| 15      | 7119     | 7146   | 4972     | 3337   | 2825     | 9528   | 0679     | 5718   | 8532      | 1909   | 45      |
| 30      | 6956     | 7351   | 4783     | 3576   | 2609     | 9801   | 0435     | 6026   | 8261      | 2251   | 30      |
| 45      | 6793     | 7555   | 4592     | 3815   | 2391     | 5.0074 | 0199     | 6333   | 7988      | 2592   | 15      |
| 39 0    | 6629     | 7759   | 4406     | 4052   | 2172     | 0346   | 6.9943   | 6639   | 7715      | 2932   | 51 0    |
| 15      | 6464     | 7962   | 4207     | 4289   | 1951     | 0616   | 9695     | 6943   | 7439      | 3271   | 45      |
| 30      | 6297     | 8165   | 4014     | 4525   | 1730     | 0886   | 9446     | 7247   | 7162      | 3608   | 30      |
| 45      | 6131     | 8366   | 3819     | 4761   | 1507     | 1155   | 9196     | 7550   | 6884      | 3944   | 15      |
| 40 0    | 5963     | 8567   | 3623     | 4995   | 1284     | 1423   | 8944     | 7851   | 6604      | 4279   | 50 0    |
| 15      | 4.5794   | 3.8767 | 5.3426   | 4.5229 | 6.1059   | 5.1690 | 6.8691   | 5.8151 | 7.6323    | 6.4612 | 45      |
| 30      | 5624     | 8967   | 3228     | 5461   | 0832     | 1956   | 8437     | 8450   | 6041      | 4945   | 30      |
| 45      | 5454     | 9166   | 3030     | 5693   | 0605     | 2221   | 8181     | 8748   | 5756      | 5276   | 15      |
| 41 0    | 5283     | 9364   | 2830     | 5924   | 0377     | 2485   | 7924     | 9045   | 5471      | 5066   | 49 0    |
| 15      | 5110     | 9561   | 2629     | 6154   | 0147     | 2748   | 7666     | 9341   | 5184      | 5935   | 45      |
| 30      | 4937     | 9757   | 2427     | 6383   | 5.9916   | 3010   | 7406     | 9636   | 4896      | 6262   | 30      |
| 45      | 4763     | 9953   | 2224     | 6612   | 9685     | 3271   | 7145     | 9929   | 4606      | 6588   | 15      |
| 42 0    | 4589     | 4.0148 | 2020     | 6839   | 9452     | 3530   | 6883     | 6.0222 | 4314      | 6913   | 48 0    |
| 15      | 4413     | 0342   | 1815     | 7066   | 9217     | 3789   | 6620     | 0513   | 4022      | 7237   | 45      |
| 30      | 4237     | 0535   | 1609     | 7291   | 8982     | 4047   | 6355     | 0803   | 3728      | 7569   | 30      |
| 45      | 4.4059   | 4.0728 | 5.1403   | 4.7516 | 5.8746   | 5.4304 | 6.6089   | 6.1032 | 7.3432    | 6.7880 | 15      |
| 43 0    | 3881     | 0920   | 1195     | 7740   | 8508     | 4560   | 5822     | 1380   | 3135      | 8200   | 47 0    |
| 15      | 3702     | 1111   | 0986     | 7963   | 8270     | 4815   | 5553     | 1666   | 2837      | 8518   | 45      |
| 30      | 3522     | 1301   | 0776     | 8185   | 8030     | 5068   | 5284     | 1952   | 2537      | 8835   | 30      |
| 45      | 3342     | 1491   | 0565     | 8406   | 7789     | 5321   | 5013     | 2236   | 2236      | 9151   | 15      |
| 44 0    | 3160     | 1680   | 0354     | 8626   | 7547     | 5573   | 4741     | 2519   | 1934      | 9466   | 46 0    |
| 15      | 2978     | 1867   | 0141     | 8845   | 7304     | 5823   | 4467     | 2801   | 1630      | 9779   | 45      |
| 30      | 2795     | 2055   | 4.9928   | 9064   | 7060     | 6073   | 4193     | 3082   | 1325      | 7.0091 | 30      |
| 45      | 2611     | 2241   | 9713     | 9281   | 6815     | 6321   | 3917     | 3361   | 1019      | 0401   | 15      |
| 45 0    | 2426     | 2426   | 9497     | 9497   | 6569     | 6569   | 3640     | 3640   | 0711      | 0711   | 45 0    |
|         | Dep.     | Lat.   | Dep.     | Lat.   | Dep.     | Lat.   | Dep.     | Lat.   | Dep.      | Lat.   |         |
|         | Dist. 6. |        | Dist. 7. |        | Dist. 8. |        | Dist. 9. |        | Dist. 10. |        | Course. |

TABLE 4.—*Condensed traverse table for cruising.*

| De-<br>grees. | Latitude.  | Departure. |               | De-<br>grees. | Latitude.  | Departure. |               |
|---------------|------------|------------|---------------|---------------|------------|------------|---------------|
| 0             | 1.000      | 0.000      | 90            | 23            | 0.920      | 0.391      | 67            |
| 1             | 1.000      | .017       | 89            | 24            | .913       | .497       | 66            |
| 2             | .999       | .035       | 88            | 25            | .906       | .423       | 65            |
| 3             | .999       | .052       | 87            | 26            | .899       | .438       | 64            |
| 4             | .998       | .070       | 86            | 27            | .891       | .454       | 63            |
| 5             | .996       | .087       | 85            | 28            | .883       | .470       | 62            |
| 6             | .995       | .104       | 84            | 29            | .875       | .485       | 61            |
| 7             | .992       | .122       | 83            | 30            | .866       | .500       | 60            |
| 8             | .990       | .139       | 82            | 31            | .857       | .515       | 59            |
| 9             | .988       | .156       | 81            | 32            | .848       | .530       | 58            |
| 10            | .985       | .174       | 80            | 33            | .839       | .545       | 57            |
| 11            | .982       | .191       | 79            | 34            | .829       | .559       | 56            |
| 12            | .978       | .208       | 78            | 35            | .819       | .574       | 55            |
| 13            | .974       | .225       | 77            | 36            | .809       | .588       | 54            |
| 14            | .970       | .242       | 76            | 37            | .799       | .602       | 53            |
| 15            | .966       | .259       | 75            | 38            | .788       | .616       | 52            |
| 16            | .961       | .276       | 74            | 39            | .777       | .629       | 51            |
| 17            | .956       | .292       | 73            | 40            | .766       | .643       | 50            |
| 18            | .951       | .309       | 72            | 41            | .755       | .656       | 49            |
| 19            | .946       | .326       | 71            | 42            | .743       | .669       | 48            |
| 20            | .940       | .342       | 70            | 43            | .731       | .682       | 47            |
| 21            | .934       | .358       | 69            | 44            | .719       | .695       | 46            |
| 22            | .927       | .375       | 68            | 45            | .707       | .707       | 45            |
|               | Departure. | Latitude.  | De-<br>grees. |               | Departure. | Latitude.  | De-<br>grees. |

TABLE 5.—*Surface measuring on slopes.*

[Increase of distance to be added to one 66' chain of surface measurement to give one chain of horizontal measurement. Approximate; for use in cruising.]

| Slope.          | Grade.           | Equiva-<br>lent verti-<br>cal angle. | Increase of<br>distance<br>per 66'<br>chain (ex-<br>secant). <sup>1</sup> |
|-----------------|------------------|--------------------------------------|---|
|                 | <i>Per cent.</i> | °                                    | <i>Links.</i>   |
| Level.....      | 5                | 3.0                                  | 0.1   |
| Gentle.....     | 10               | 5.5                                  | .5  |
|                 | 15               | 8.5                                  | 1.1   |
| Moderate.....   | 20               | 11.5                                 | 2.0   |
|                 | 30               | 16.5                                 | 4.4   |
|                 | 40               | 22.0                                 | 7.8   |
| Steep.....      | 50               | 26.5                                 | 11.7  |
|                 | 60               | 31.0                                 | 16.6  |
|                 | 70               | 35.0                                 | 22.1  |
|                 | 80               | 38.5                                 | 28.0  |
| Very steep..... | 90               | 42.0                                 | 34.6  |
|                 | 100              | 45.0                                 | 41.4  |

The per cent of grade is determined by grademeter or hypsometer.

Vertical angles are read by clinometer, Abney level, or transit.

<sup>1</sup> The exsecant is a ratio of links per 100 links (=1 chain), and therefore the figures in this column also show feet per 100 feet, or yards per 100 yards, etc.

## BLAZES AND MARKS ON TREES.

Trees should never be blazed nor marked upon random or trial lines nor upon other preliminary or temporary surveys, where they may be misleading in the future.

A survey *line* is *blazed* in order that it may be located or retraced between corners which are at each end of the line. *Corners* and *intersections* are witnessed by *marks*. Thus the ax scars used in surveying may be either blazes or marks, one term being applied to a line and the other to a point. In some books on surveying these terms have been used interchangeably or carelessly, but it is better to make the distinction in the Forest Service, where surveying is done for so many different purposes.

A survey *line* is *blazed* in the following manner: Trees which are on the line are blazed fore and back, meaning that the surveyor took a foresight when running toward the tree and a backsight when running away from it, on the same straight line. Such a tree is called a line tree and is spoken of as being line-blazed. Trees standing near the line, within 50 links on either side, are blazed on two sides quartering toward the line.

Blazes for roads need not be permanent because the subsequent construction of the highway fixes the line. Property lines should be permanently blazed—that is, through the bark to the wood, leaving a scar which may be recognized or found as long as the tree stands. Blazes should be the width of an ax blade, about 6 inches long, and placed breast high. When it is probable that the blazes will be used when there is deep snow upon the ground, they should be placed high enough to be seen, or the trees may be given a

second blazing at a higher point after the deep snow renders this convenient.

It is often desirable, as in the case of trails, that Forest Service blazes should be distinguished from land office blazes or from private surveys, and, therefore, a distinctive blaze has been adopted for the Forest Service. This is the width of an ax blade, about 6 inches long, with a horizontal notch at the top of the scar.

The Forest Service has also adopted a distinctive *mark* to indicate the *intersection* of one of its lines with a land office line and to show the approximate distance to the nearest land office corner. Thus, when a road or trail crosses a section line a tree may be marked in such a manner that any Forest officer may recognize it, and will know the direction and approximate distance to the nearest section or quarter-section corner. This mark is made in the following manner: A tree near the point of intersection is barked to the wood, about 8 by 10 inches, on the side facing the corner. A letter C with horizontal crossbars is then scribed upon the scar. A horizontal bar will indicate that the distance to the corner is about 10 chains, and each half bar will indicate a distance of about 5 chains. For example, the intersection marks may read as follows:



About 5  
chains to  
corner.



About 10  
chains to  
corner.



About 15  
chains to  
corner.



About 20  
chains to  
corner.



About 25  
chains to  
corner.



It will sometimes happen that an intersection tree can not be marked facing the corner and at the same time have the mark visible from the trail or road. In such cases the mark will face the corner and an X will be cut, through the bark, on the side toward the highway. The letter X is a recognized symbol, indicating the crossing of lines or to indicate that a trail crosses a stream at this point. It is often useful in the latter case when there is snow on the ground, as it shows that the stream must be forded, and that the trail will be found on the other side. It will, therefore, be used for both purposes mentioned, and its meaning will never be misunderstood. The letter Y is often used to indicate that the trail forks at this point, and is useful when there is snow upon the ground.

It will frequently happen that a land-office corner will be accidentally found, and the distance from it to the point of intersection will be immediately determined by pacing. This is sufficiently accurate to warrant the marking of an intersection witness tree, as stated above, as the distance is only presumed to be approximate. Whether the line is paced or measured, the ranger will make a record in his notebook, describing the land-office corner and the distance to the intersection, and the marks which he placed at that point. The following is a specimen of such a record:

#### SPECIMEN RECORD.

October 4, 1912, 10 a. m. I found the quarter-corner between sections 15 and 16, T. 8 N., R. 21 W. Both witness trees were standing, but the stake had fallen over. The rotted point was found in the ground and I reset the stake above it, placing a mound of stones about it to hold it in position. From this corner I paced south, following the original blazes, 23 chains, to the intersection

of the new Forest Service trail between Wild Cat Ranger Station and Alta Lookout Point. Established for witness red fir 20 inches in diameter, on north side of trail, 40 links distant from intersection, marked € on north side and X on south side.

October 4, 6 p. m. Made a record of the above information on the atlas sheet.

JOHN R. UNDERWOOD,  
*Ranger.*

It is important that any geographic information which may be used to correct the atlas sheets, and thus lead to the preparation of accurate forest maps, should be placed upon the sheets which are kept for that purpose by each forest officer. All of such corrections or additional data should be transmitted to the supervisor as he may require them, but certainly in ample time for him to include them in the corrected folio which he sends to the Forester on February 1 of each year.

Other marks used by the Forest Service are described under "Ranger station surveys" and "Forest homestead surveys."

### FIELD NOTES.

Notes of survey should show exactly what was done in the field, including the errors of courses or measurements. In resurveying lines, it is no reflection on the survey party if it does not "check up" exactly, but it is rather expected that a trial or "random line" will not strike a corner nor the measurement prove exactly as "returned" by the original surveyor. It is important, however, to know what the error or difference is discovered to be.

When a notebook contains the field notes of only one survey, the purpose of which the survey was made should be plainly marked on the cover as well as on

the first page. If it contains the notes of more than one survey, the title of a survey should be written at the top of each page, and the book should be indexed on the first page. Each book should be numbered and paged. When the notes for a survey do not follow in regular order in a notebook be sure to refer to the page where the continuation can be found and at that point refer back by page number to the former notes.

It is a good plan to make numerous explanatory sketches on the right-hand pages of the notebooks, leaving nothing to the memory, and particularly the direction of the flow of streams should be shown by arrows. If the surveyor will always imagine that he might stop work at any moment, and some one else may be obliged to continue the survey, and will keep his notes so clearly that this would be easy, then they are apt to be a reliable record. Never erase notes—cross them out and mark them “abandoned.”

Field notes should never be crowded into a notebook or be written as a continuous recital, but should be tabulated clearly that they may be readily platted by any surveyor or draftsman. A good form for keeping notes is here shown.

## SPECIMEN NOTES.

..... National Forest.

Resurvey of east boundary of sec. 24, T. 19 N., R. 14 E.

June 16, 1912.

Weather clear.

I corrected both *aneroids* at the benchmark at . . . . which has an elevation of . . . . ft.

Made camp 5.30 p. m. Sec. 24, T. 19 N., R. 14 E.

7 p. m. Camp barometer reads 4,850'.

Field barometer reads 4,860'.

At 9 p. m. observed *Polaris* and find the variation at camp to be 19° east.

June 17, 1912.

Weather clear.

7 a. m. Camp barometer 4,850'.

Field barometer 4,860'.

*Resurvey* of east boundary of sec. 24, T. 19 N., R. 14 E., in the . . . . National Forest. The *original survey* was made in 1872, with variation  $18\frac{1}{2}^{\circ}$  east. Allowing for the reported increase, the variation should be about  $19^{\circ} 05'$ .

Elev.

From the southeast corner of sec. 24. . . . . 4,780'

Ran *north*, var.  $19^{\circ}$  east.

|            |  |        |
|------------|--|--------|
| 10. 00 ch. | near 36'' yellow pine. . . . .   | 4,720' |
| 20. 00     | in thicket of firs. . . . .  | 4,680' |
| 24. 50     | creek, 4 links wide, flows SW. . . . .                                 | 4,660' |
| 30. 00     | at foot of steep slope. . . . .  | 4,740' |
| 40. 00     | on steep sidehill, SE. . . . .   | 4,920' |
| 40. 23     | to a point 15 links west of $\frac{1}{4}$ corner on east side sec. 24. |        |

On this line the original blazes were almost obliterated, and I made new blazes.

From the  $\frac{1}{4}$  corner on east side of sec. 24.Ran *north*, var.  $19^{\circ}$  east.

|            |                                 |        |
|------------|---------------------------------|--------|
| 10. 00 ch. | enter burned area. . . . .      | 5,050' |
| 13. 60     | top of hill NE. and SW. . . . . | 5,120' |

From this point I take *vertical angles* on some high points in unsurveyed T. 19 N., R. 15 E., as follows:

Elev..

|                       |  |        |
|-----------------------|--|--------|
| N. $24\frac{1}{4}$ E. | 3 miles, vertical angle $1\frac{1}{2}^{\circ}$ . . . . .             | 5,545' |
| N. $37\frac{1}{4}$ E. | $2\frac{1}{4}$ miles, vertical angle $\frac{1}{4}^{\circ}$ . . . . . | 5,179' |
| N. $89^{\circ}$ E.    | ? miles, vertical angle $1\frac{3}{4}^{\circ}$ . . . . .             |        |
| S. $43\frac{1}{2}$ E. | 4 miles, vertical angle $1^{\circ}$ . . . . .                        | 5,503' |
| S. $10^{\circ}$ E.    | $3\frac{1}{4}$ miles, vertical angle $\frac{3}{4}^{\circ}$ . . . . . | 5,355' |

thence continue *north*.

|        |   |        |
|--------|---|--------|
| 20. 00 | heavy litter. . . . .   | 5,075' |
| 27. 30 | leave burn. . . . .   |        |
| 30. 00 | in good reproduction yellow pine. . . . .   | 4,900' |
| 39. 85 | to a point 20 links east of NE. cor. of sec. 24. Witness trees standing, but stake almost destroyed. Set new stake with the proper marks and U. S. F. S. on SW. side. . . . . | 4,850' |
|        | etc., etc.  |        |

7 p. m. Camp barometer, 4,870'.

Field barometer, 4,880'.

## ROAD, STREAM, OR SUMMIT MEANDERS.

The method of keeping meander notes differs from the above. Each course begins a new tally, and any intermediate distances are entered in a third column. The second column may then be added to determine the total distance surveyed, viz:

..... National Forest.

Meanders in unsurveyed T. 19 N., R. 15 E.

June 18, 1912.

Weather cloudy.

7 a. m. Camp barometer, 4,880'.

Field barometer, 4,890'.

From a point 13.60 ch. north of  $\frac{1}{4}$  cor. on the east side of sec. 24.

Ran *along summit*, var. 19° east.

|                     |                                       |         |
|---------------------|---------------------------------------|---------|
| N. 24               | E. 9.00 ch. at 6.00 leave burn.....   | 5, 200' |
| N. 39 $\frac{1}{2}$ | E. 17.50 at 3.00 trail N. and S.....  | 5, 125' |
| N. 48 $\frac{1}{4}$ | E. 11.20 .....                        | 5, 175' |
| S. 86               | E. 14.60 highest point on summit..... | 5, 320' |

At this point the summit divides; one branch bearing SE. and the other SW.

Continuing the meanders:

Ran *down gulch*, between the two divides.

Var. 19° east.

|            |  |         |
|------------|--|---------|
| N. 89      | E. 18.00 ch. spring.....   | 5, 150' |
| N. 75      | E. 15.00 meadow, 2 acres.....  | 5, 025' |
| S. 83      | E. 4.00 falls, 10 feet.....  | 4, 975' |
| N. 80      | E. 22.20 at 18.00 small tributary from the south ..  | 4, 900' |
| N. 86      | E. 9.00 at 2.30 the notice of the Morning Star<br>mining claim bears S. 1.50; at 3.40<br>mining cabin..... | 4, 875  |
| etc., etc. |  |         |

TABLE 6.—*Difference of altitude between the "station" occupied by the surveyor, of which the altitude is known, and a higher distant object whose altitude is desired.*

[Difference of altitude in feet—add to station altitude.]

| Vertical<br>angle<br>above<br>a level<br>line. | Distance to object, in miles. |       |       |       |       |       |       |       |       |       |
|--|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|  | 1                             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 0°00'  | 5                             | 7     | 10    | 14    | 19    | 25    | 33    | 41    | 51    | 62    |
| 15   | 28                            | 53    | 79    | 106   | 134   | 163   | 194   | 225   | 258   | 292   |
| 30   | 51                            | 99    | 148   | 198   | 249   | 301   | 356   | 410   | 466   | 523   |
| 45   | 74                            | 145   | 217   | 290   | 365   | 440   | 517   | 594   | 673   | 753   |
| 1°00'  | 97                            | 191   | 286   | 383   | 480   | 578   | 678   | 778   | 880   | 984   |
| 15   | 120                           | 237   | 356   | 475   | 595   | 716   | 839   | 963   | 1,088 | 1,214 |
| 30   | 143                           | 283   | 425   | 567   | 710   | 855   | 1,001 | 1,147 | 1,295 | 1,445 |
| 45   | 166                           | 330   | 494   | 659   | 826   | 993   | 1,162 | 1,332 | 1,503 | 1,675 |
| 2°00'  | 189                           | 376   | 563   | 752   | 941   | 1,131 | 1,324 | 1,516 | 1,710 | 1,906 |
| 15   | 212                           | 422   | 632   | 844   | 1,056 | 1,270 | 1,485 | 1,701 | 1,918 | 2,137 |
| 30   | 235                           | 468   | 702   | 936   | 1,172 | 1,408 | 1,647 | 1,885 | 2,126 | 2,367 |
| 45   | 259                           | 514   | 771   | 1,028 | 1,287 | 1,547 | 1,808 | 2,070 | 2,334 | 2,598 |
| 3°00'  | 282                           | 560   | 840   | 1,121 | 1,403 | 1,685 | 1,970 | 2,255 | 2,541 | 2,829 |
| 15   | 305                           | 607   | 909   | 1,213 | 1,518 | 1,824 | 2,132 | 2,440 | 2,749 | 3,060 |
| 30   | 328                           | 653   | 979   | 1,306 | 1,634 | 1,963 | 2,294 | 2,625 | 2,957 | 3,291 |
| 45   | 351                           | 699   | 1,048 | 1,398 | 1,749 | 2,101 | 2,455 | 2,810 | 3,166 | 3,523 |
| 4°00'  | 374                           | 745   | 1,118 | 1,491 | 1,865 | 2,240 | 2,617 | 2,995 | 3,374 | 3,754 |
| 15   | 397                           | 792   | 1,187 | 1,583 | 1,981 | 2,379 | 2,780 | 3,180 | 3,582 | 3,986 |
| 30   | 420                           | 838   | 1,257 | 1,676 | 2,097 | 2,518 | 2,942 | 3,365 | 3,791 | 4,217 |
| 45   | 444                           | 884   | 1,326 | 1,769 | 2,213 | 2,657 | 3,104 | 3,551 | 4,000 | 4,449 |
| 5°00'  | 467                           | 931   | 1,396 | 1,862 | 2,329 | 2,797 | 3,267 | 3,737 | 4,208 | 4,681 |
| 15   | 490                           | 977   | 1,466 | 1,955 | 2,445 | 2,936 | 3,429 | 3,922 | 4,418 | 4,914 |
| 30   | 513                           | 1,024 | 1,535 | 2,048 | 2,561 | 3,075 | 3,592 | 4,108 | 4,627 | 5,146 |
| 45   | 537                           | 1,070 | 1,605 | 2,141 | 2,677 | 3,215 | 3,755 | 4,294 | 4,836 | 5,379 |
| 6°00'  | 560                           | 1,117 | 1,675 | 2,234 | 2,794 | 3,355 | 3,918 | 4,481 | 5,046 | 5,612 |
| 15   | 583                           | 1,164 | 1,745 | 2,327 | 2,910 | 3,495 | 4,081 | 4,667 | 5,255 | 5,845 |
| 30   | 607                           | 1,210 | 1,815 | 2,420 | 3,027 | 3,634 | 4,244 | 4,854 | 5,465 | 6,078 |
| 45   | 630                           | 1,257 | 1,885 | 2,514 | 3,144 | 3,775 | 4,407 | 5,040 | 5,675 | 6,311 |
| 7°00'  | 653                           | 1,304 | 1,955 | 2,607 | 3,261 | 3,915 | 4,571 | 5,227 | 5,886 | 6,545 |
| 15   | 677                           | 1,350 | 2,025 | 2,701 | 3,378 | 4,055 | 4,735 | 5,415 | 6,096 | 6,779 |
| 30   | 700                           | 1,397 | 2,095 | 2,795 | 3,595 | 4,196 | 4,899 | 5,602 | 6,307 | 7,013 |
| 45   | 724                           | 1,444 | 2,166 | 2,888 | 3,612 | 4,337 | 5,063 | 5,790 | 6,518 | 7,248 |
| 8°00'  | 747                           | 1,491 | 2,236 | 2,982 | 3,729 | 4,477 | 5,227 | 5,977 | 6,729 | 7,483 |
| 15   | 771                           | 1,538 | 2,307 | 3,076 | 3,847 | 4,618 | 5,392 | 6,166 | 6,941 | 7,718 |
| 30   | 794                           | 1,585 | 2,377 | 3,170 | 3,964 | 4,760 | 5,557 | 6,354 | 7,153 | 7,953 |
| 45   | 818                           | 1,632 | 2,448 | 3,265 | 4,082 | 4,901 | 5,722 | 6,542 | 7,365 | 8,189 |

TABLE 6.—*Difference of altitude between the "station" occupied by the surveyor, of which the altitude is known, and a higher distant object whose altitude is desired—Continued.*

[Difference of altitude in feet—add to station altitude.]

| Vertical<br>angle<br>above<br>a level<br>line. | Distance to object, in miles. |       |       |       |       |       |       |       |       |        |
|--|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
|  | 1                             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10     |
| 9°00'  | 841                           | 1,680 | 2,519 | 3,359 | 4,200 | 5,043 | 5,887 | 6,731 | 7,577 | 8,425  |
| 15   | 865                           | 1,727 | 2,590 | 3,454 | 4,319 | 5,185 | 6,053 | 6,920 | 7,790 | 8,661  |
| 30   | 889                           | 1,774 | 2,661 | 3,548 | 4,437 | 5,327 | 6,218 | 7,109 | 8,003 | 8,898  |
| 45   | 912                           | 1,821 | 2,732 | 3,643 | 4,556 | 5,469 | 6,384 | 7,299 | 8,217 | 9,135  |
| 10°00'   | 936                           | 1,869 | 2,803 | 3,738 | 4,674 | 5,611 | 6,550 | 7,489 | 8,430 | 9,372  |
| 15   | 960                           | 1,917 | 2,874 | 3,833 | 4,793 | 5,754 | 6,717 | 7,679 | 8,644 | 9,610  |
| 30   | 984                           | 1,964 | 2,946 | 3,928 | 4,912 | 5,897 | 6,883 | 7,870 | 8,858 | 9,848  |
| 45   | 1,007                         | 2,012 | 3,017 | 4,024 | 5,031 | 6,040 | 7,050 | 8,061 | 9,073 | 10,087 |
| 11°00'   | 1,031                         | 2,060 | 3,089 | 4,119 | 5,151 | 6,183 | 7,217 | 8,252 | 9,288 | .....  |
| 15   | 1,055                         | 2,108 | 3,161 | 4,215 | 5,270 | 6,327 | 7,385 | 8,443 | 9,504 | .....  |
| 30   | 1,079                         | 2,155 | 3,233 | 4,311 | 5,390 | 6,470 | 7,553 | 8,635 | 9,719 | .....  |
| 45   | 1,103                         | 2,204 | 3,305 | 4,407 | 5,510 | 6,615 | 7,721 | 8,827 | 9,935 | .....  |
| 12°00'   | 1,127                         | 2,252 | 3,377 | 4,503 | 5,631 | 6,759 | 7,839 | 9,019 | ..... | .....  |
| 15   | 1,151                         | 2,300 | 3,449 | 4,600 | 5,751 | 6,904 | 8,058 | 9,212 | ..... | .....  |
| 30   | 1,176                         | 2,348 | 3,522 | 4,696 | 5,872 | 7,048 | 8,227 | 9,405 | ..... | .....  |
| 45   | 1,200                         | 2,397 | 3,594 | 4,793 | 5,993 | 7,194 | 8,396 | 9,599 | ..... | .....  |
| 13°00'   | 1,224                         | 2,445 | 3,667 | 4,890 | 6,114 | 7,339 | 8,566 | ..... | ..... | .....  |
| 15   | 1,248                         | 2,494 | 3,740 | 4,987 | 6,235 | 7,485 | 8,736 | ..... | ..... | .....  |
| 30   | 1,273                         | 2,542 | 3,813 | 5,084 | 6,357 | 7,631 | 8,906 | ..... | ..... | .....  |
| 45   | 1,297                         | 2,591 | 3,886 | 5,182 | 6,479 | 7,777 | 9,077 | ..... | ..... | .....  |
| 14°00'   | 1,321                         | 2,640 | 3,959 | 5,280 | 6,601 | 7,924 | ..... | ..... | ..... | .....  |
| 15   | 1,346                         | 2,689 | 4,033 | 5,378 | 6,724 | 8,071 | ..... | ..... | ..... | .....  |
| 30   | 1,371                         | 2,738 | 4,107 | 5,476 | 6,847 | 8,218 | ..... | ..... | ..... | .....  |
| 45   | 1,395                         | 2,787 | 4,180 | 5,574 | 6,970 | 8,366 | ..... | ..... | ..... | .....  |
| 15°00'   | 1,420                         | 2,837 | 4,254 | 5,673 | 7,093 | ..... | ..... | ..... | ..... | .....  |
| 15   | 1,444                         | 2,886 | 4,327 | 5,771 | 7,216 | ..... | ..... | ..... | ..... | .....  |
| 30   | 1,469                         | 2,935 | 4,402 | 5,870 | 7,339 | ..... | ..... | ..... | ..... | .....  |
| 45   | 1,494                         | 2,985 | 4,477 | 5,970 | 7,463 | ..... | ..... | ..... | ..... | .....  |

This table is corrected for earth curvature, refraction, and the height of the instrument used at the station ( $4\frac{1}{2}$  feet).

**ELEVATIONS FROM VERTICAL ANGLES.**

When the distance to a mountain or other object is known its elevation above the surveyor may be determined. A vertical angle is measured with a clinometer or clinometer-compass, and the difference in elevation can be determined from the table. Information of this character assists greatly in the preparation of a map, and this method should be used when a peak is inaccessible or not likely to be occupied during the present survey. If both the distance and elevation of a peak are known, and the surveyor desires the elevation of the station which he is then occupying, this process is easily reversed. The table is prepared to miles of distance, and if intermediate fractional miles are needed the ratio may be interpolated.

The method of determining the distance of a peak or other salient topographic point is illustrated in the various plane-table methods. If compass sights are taken from two or more known points the intersections may be platted with a protractor or computed.<sup>1</sup>

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<sup>1</sup> The following is the method of computing the sides of a triangle when two angles and one side are known: The angle opposite the known side is equal to  $180^\circ$  minus the sum of the two known angles. The sine of an angle is the same as its departure (in the traverse table) for distance 1. *A* and *B* represent the two known angles and their distance apart; *C* is the opposite angle:

Then:

$$\frac{\text{Distance } AB \times \text{sine of angle } B}{\text{Sine of angle } C} = \text{distance } AC$$

Or:

$$\frac{\text{Distance } AB \times \text{sine of angle } A}{\text{Sine of angle } C} = \text{distance } BC$$

The traverse table, distance 1, being the same as a table of natural cosines and sines, may be used to change a slope measurement to a horizontal measurement, and also get the difference in elevation. Thus a distance of 10.00 chains up or down a  $7^\circ$  slope would represent 9.92 chains on the level, and 1.22 chains rise or fall. The same method is used in reducing stadia measurements.



TYING IN.

It is frequently necessary to make surveys of ranger stations or for timber sales in areas which have not been previously surveyed or mapped. It is imperative that some connection should be surveyed between the nearest or most convenient established point and the initial point of the survey which is to be made. Otherwise the survey will not determine the location of the area under consideration. The nature of the country and the distance necessary to be run will suggest which of the following methods may be employed:

(1) Measure a line north, south, east, or west to intersect a Government survey line. Then tie to the nearest corner, quarter corner, meander corner, mile-post, grant corner, or other point which is of official record.

(2) Or run a traverse (meander) over a road, trail, open or easy country to such points.

(3) Or if no land office surveys have been made nearer than, say, 5 miles, but there is a Geological Survey sheet, then tie to a bench mark, triangulation station, forks of a road, forks of a stream which has not changed its bed, or a house which is shown on the sheet. Accompany your report with a tracing or description which will show unmistakably the point used. If you tie to a mineral monument or to some corner of a patented mining claim, give a clear description.

(4.) Or if no official surveys have been made within practicable distance, proceed as follows: Establish and witness a permanent monument, marked F S M. This may be at the initial point of your survey. From

this point run a traverse to some outlook where compass or plane-table bearings may be taken on a number of peaks or other definite landmarks which may be visible. Give their estimated distances. State approximately what unsurveyed section the land would be in, or its latitude and longitude. The map accompanying such a survey should show any divide, stream, or trail in the immediate vicinity, and particularly the name of the watershed.

### RANGER STATION SURVEYS.

When the lands have been surveyed by the General Land Office and the corners can be located, the plat only need be submitted, showing the subdivisions desired for a ranger station. Where lots occur their numbers should be shown on the plat. No other description is necessary. The determination of the correct subdivisions must not be left to conjecture. The land office corners should be located and the necessary lines carefully run in every case when there is the least doubt as to what forties or tens should be recommended for withdrawal.

When the lands are unsurveyed, or the corners of the Government survey can not be located, the actual boundary lines must be surveyed and marked, and field notes, description, and a plat must be prepared, all in accordance with the following instructions:

Three kinds of permanent points of identification will be established—*Forest Service Monuments*, to which the ranger station surveys, and possibly future homestead or timber surveys, will be tied by bearing and distance;

*corners*, which will be set up at each angle in the boundary; and *witnesses*, to which, whenever possible, each monument and corner will be tied.

*Forest Service Monuments.*—The object of these monuments is explained under the subject “Tying in.” They will be similar to the mineral monuments of a mining district. They should, if possible, be immovable and durable, and easy to locate at any future time from the field notes of the survey. A large bowlder or a built-up stone monument will serve the purpose, or a sound tree of long-lived species. Where there are no trees a wooden post may be used. Monuments will be marked F S M The *witnesses* for a monument should be permanent objects from which at least two cross bearings can be taken to locate the monument in the future if necessary. They will be marked  $\begin{matrix} M \\ W \end{matrix}$ .

At each angle in the boundary of a *ranger station* a durable *corner* will be established similar to those of the land-office surveys. Each corner post or stone will be marked near its top with the letter R and below this the number of the angle at which the corner is set, beginning with the initial post as number 1 and counting on in regular sequence around the boundary in the direction of the survey. Thus the monument of the third corner will be marked  $\begin{matrix} R \\ 3 \end{matrix}$

At least two *witnesses* will be made near each corner, and will be marked with the letter W and the number of the corner, thus:  $\begin{matrix} W \\ 3 \end{matrix}$

If the monument is established at the initial point of a survey, and is therefore also corner number 1, it will bear both monument and corner markings, thus:

F S M  $\overset{R}{1}$  The witnesses will then bear the letters  $\overset{M}{W}$   
with the figure 1 beneath, thus:  $\overset{M}{W}$   
1

The surveyor will depend largely on his common sense and skill in selecting trees or prominent rocks in the best positions for witnesses. Frequently the corners can be established near good witnesses without diminishing the value of the station. Usually the witnesses should not be more than 3 chains from a corner—the nearer the better, but they should be inside the boundary if possible.

Where the boundary line of the ranger station passes through timber, the line should be plainly blazed in the manner described on page 41.

The instructions regarding field notes (p. 44) must be followed. A good form for keeping them is here shown:

SPECIMEN NOTES.

..... National Forest.

WILDCAT RANGER STATION.

T. 25 N., R. 8 E., Section ....., ..... Meridian. Number ..... List ..... Area, 33.63 acres.

June 15, 1912.

Weather cloudy.

*Variation.*—This survey was made with a Forest Service standard compass. Variation,  $11^{\circ} 30' E.$ , was obtained by retracement of east line of Section 36, T. 25 N., R. 7 E. The local land office recommends using a variation of  $11^{\circ}$  to  $11^{\circ} 40'$  in this vicinity.

*Forest Service Monument.*—Consists of a boulder  $7' \times 6' \times 3'$  above ground, situated on the left bank of Wildcat Creek, 7 chains downstream from the juncture of the north and east forks, 70 links from the water's edge, at right angles to the stream. F S M cut on the

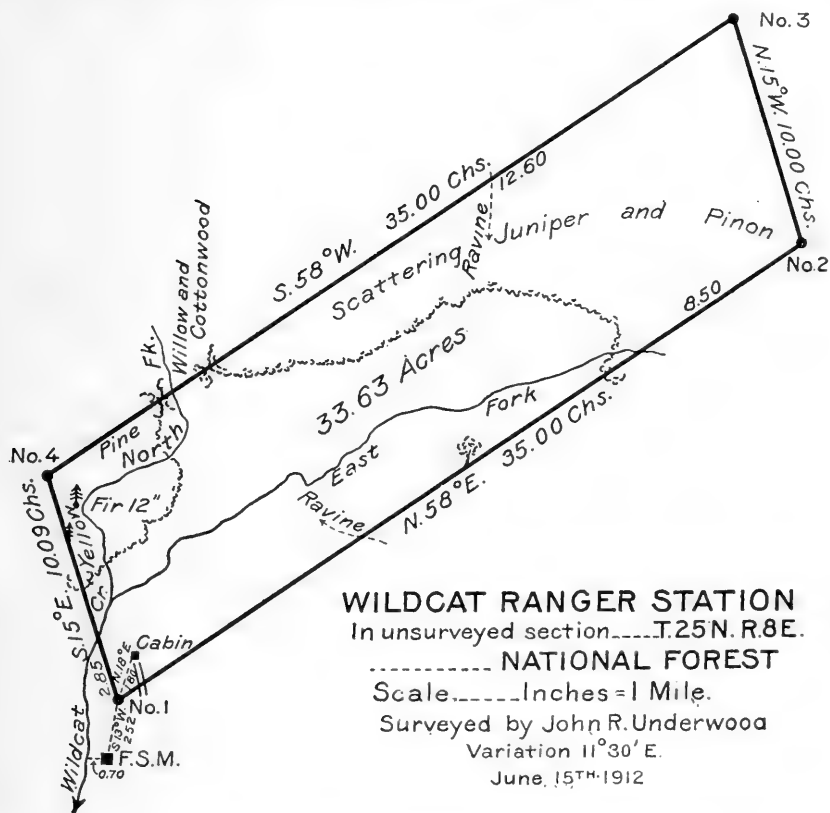


FIG. 11.—Ranger station plat.

highest point of the rock, whence a yellow pine 16 inches in diameter bears  $N. 16^{\circ} E.$ , 73 links distant, marked  $\frac{M}{W}$  in blaze. Lyon Mountain bears  $S. 31^{\circ} 30' W.$  Tiger Mountain bears  $N. 28^{\circ} 30' W.$  Rock ledge bears  $S. 54^{\circ} W.$ , 47 links distant, marked  $\frac{M}{W}$

## 56 INSTRUCTIONS FOR MAKING FOREST SURVEYS, ETC.

Beginning at corner No. 1, a limestone  $30'' \times 9'' \times 5''$  set in mound of stones and chiseled  $R_1$

Forest Service Monument above described bears S.  $13^\circ$  W., 252 links distant.

The SW. corner of the ranger's cabin, built in 1905, bears N.  $18^\circ$  E., 180 links distant.

A yellow pine, 12 inches diameter, bears east, 298 links distant marked  $W_1$

*Thence N.  $58^\circ$  E.*

1.20 chs. road, N. and S.  
 12.40 ravine, course NW.  
 17.80 leaning scrubby pinon 16 inches diameter.  
 25.00 enter scattering juniper and pinon.  
 26.50 East Fork Wildcat Creek flows N.  $89^\circ$  W.  
 35.00 corner No. 2, a juniper post  $5' \times 4'' \times 4''$  in mound of gravel and earth, at foot of slope, marked  $R_2$

A pinon, 8 inches diameter, bears north 10 links distant, marked  $W_2$

A granite boulder, 4 feet in diameter and 3 feet above ground, bears S.  $82^\circ$  E., 223 links distant, marked  $W_2$

*Thence N.  $15^\circ$  W.*

2.00 ascend slope, through small scrubby pinon.  
 10.00 corner No. 3, a limestone  $3'' \times 7'' \times 26''$  in mound of stone, marked  $R_3$  on SW. slope of a hill, about 150 feet above the ranger cabin.

Chimney of cabin bears S.  $45^\circ 30'$  W.

No suitable witness objects within 3.00 chains.

*Thence S. 58° W.*

(There is evidently local attraction at this point, since my backsight reading is S. 14° E. The compass needle therefore reads S. 59° W. on this course.)

Running down slope.

- 12.60 ravine, course south.  
 26.80 foot of slope. Leave pinon, enter willows and cotton-wood.  
 28.53 cross north fork of Wildcat Creek, flows S. 18° E.  
 29.00 enter open yellow pine timber.  
 35.00 corner No. 4. A stake of pine heartwood in mound of earth, marked  $\frac{R}{4}$

A yellow pine, 2 feet in diameter, bears N. 14° E., 18 links distant, marked  $\frac{W}{4}$

A fir, 12 inches diameter, standing on right bank of north fork of Wildcat Creek, bears S. 42° 30' E., 134 links distant, marked  $\frac{W}{4}$

(As my backsight reading is now N. 58° E., I conclude that there is no local attraction at this point.)

*Thence S. 15° E.*

through open pine timber.

- 2.96 pine tree 2½ feet in diameter.  
 5.00 leave pine timber.  
 7.24 cross Wildcat Creek flows S. 23° W.  
 10.09 corner No. 1, the place of beginning, containing 33.63 acres of land, be the same more or less.

JOHN R. UNDERWOOD,  
*Ranger Surveyor.*

Field notes and plat compared and approved by—

GEORGE A. OVERMAN,  
*Supervisor.*

## FOREST HOMESTEAD SURVEYS.

These surveys will be made in the same manner as those for ranger stations, but to avoid some confusion and to distinguish them the following system of marks should be used:

Forest Service *monuments*, which are established for homestead surveys, will be marked F S M H *Witnesses* for these monuments will be marked  $\begin{smallmatrix} M & H \\ & W \end{smallmatrix}$  *Corners* will be marked with H and the number of the corner, thus:  $\begin{smallmatrix} H \\ 2 \end{smallmatrix}$  and a *witness* to the same corner will be  $\begin{smallmatrix} H & W \\ & 2 \end{smallmatrix}$  When a monument is also the initial point of the survey, and is therefore also corner number 1 it will bear both marks, thus:  $\begin{smallmatrix} F & S & M & H \\ & & 1 \end{smallmatrix}$

If a F S M is subsequently used as a tie for a forest homestead survey its original marks will not be changed. In like manner a F S M H may be used as a tie for a ranger station or other subsequent survey without changing the original marks. The field notes will, of course, show unmistakably what tie was used.

The type of cover of the land must be clearly shown on the map accompanying the reports. For this purpose Forest Atlas Legend crayons or color tints will be used.

The establishment of corners will not be required where it can be conclusively shown in a written report that listing of the land should be denied.

The surveyor should be thoroughly familiar with the instructions under the act of June 11, 1906. Attention



is also called to the circular of the General Land Office, September 7, 1906, "Regulations Governing Entries within Forest Reserves."

A cooperative agreement between the Departments of the Interior and Agriculture, dated September 19, 1911, to avoid duplication or unnecessary work in surveying forest homestead claims, provides that instead of two surveys, as heretofore required, there shall be but one survey, and that it may be made by a forest officer, designated by and acting under the direction of the surveyor general, "who will exercise supervision in every case as to the manner of the execution of the survey with reference to the running of lines and the establishment of monuments to mark the same."

Such surveys are for the approval of the surveyor general and acceptance by the General Land Office. The instructions of the surveyor general will be followed in these cases, even though they conflict entirely or in part with the methods of the Forest Service.

### TRAIL SURVEYS.

In surveying for railways, roads, or trails, the *vertical deflection* of the line is always expressed in *per cent*. Thus, a 5 per cent grade means a rise of 5 feet in 100 feet of horizontal distance. The *horizontal deflection* of the line is always expressed in *degrees*. Thus, a railway may have a  $3^{\circ}$  curve, which is a horizontal deflection of  $3^{\circ}$  in 100 feet, from chord to chord. or a road may have a change in direction of  $3^{\circ}$  at the junction of two courses. *Percentage* of grade and *degrees* of azimuth should never be confounded, as very serious errors will result. The terms are never interchangeable.

The most important thing about a trail is its grade. Any other feature of its construction may be improved from month to month or from year to year, but if the grade is not properly established it must in time be abandoned. Thus, not only may time and money be wasted, but the trail, while in use, would be unsatisfactory. On the other hand, if the grade is properly located, the trail will be useful as soon as it is passable.

The best gradient between any two points is upon a line which would have the same percentage of rise from beginning to end. Often there are "salient points" along the route, above or below which the grade must run, and we must then think of the line as divided into parts, each with its own percentage of rise between these salient points. If an even gradient is also a low gradient, it is unquestionably the proper location for the trail if construction is practicable. The same is true if the gradient is on the most direct and practical route and is below the maximum for trails.

Reverse grades should be avoided if possible. This means that we should never go downhill when the object is to go uphill, as this obviously increases the elevation to be climbed, and therefore increases the grade upon the ascending portions of the trail.

There are three maxima grades for trail construction. These are: 6 per cent, 12 per cent, and 18 per cent. Being multiples of 6, these are easy to remember, as are also the reasons for having several maxima. A good grade, having a maximum of 6 per cent, may later be developed into a first-class road or turnpike. Such a grade might be called, for convenience, a *turnpike*

*grade*. The surveyor should try his very best to get the trail upon a turnpike grade, but if this is obviously impracticable, he should keep the grade as low as possible, and not exceed 12 per cent. This is the limit for safe mountain roads such as are used for freighting, and might properly be called a *freight grade*. When trails must be constructed upon grades steeper than this, or to places which roads can not reach for many years, it is simply a case of making the best location the circumstances permit. However, there is still the final limit which should not be exceeded. This is the *trail grade* of 18 per cent, and is as steep as a loaded pack animal can ascend without violent and exhaustive effort. Long steep grades should have breaks at intervals where animals may rest and recover.

In deciding on a route or location, the following points should be considered.

(1) A south exposure has less snow, is dryer, often more open, and has an increased fire hazard.

(2) Slide rock and other unstable material make a temporary or dangerous tread.

(3) Steep side hills, near the angle of repose, are liable to landslides or snowslides.

(4) Bridges and temporary structures should be avoided as far as possible.

(5) The permanence of a trail depends on the material and its drainage.

It will be seen from the above that the location of a trail grade is almost wholly a matter of experience and good judgment.

The aneroid barometer is often used to determine the distance in elevation between the ends of the proposed trail, and the approximate distance may be determined by pacing. This furnishes a preliminary reconnaissance. A "trial" or "random" line may then be run from one end of the proposed line to the other on the approximate average grade, which has been determined by reconnaissance. This may be done by a grademeter, an Abney level, or a Locke level.

The grademeter is used as described on page 29. As the circular pendulum is graduated to tangents it may be used to line in the grade to any desired per cent, either uphill or downhill. It is unnecessary to consider the matter of distance, because grade, as thus measured, is an absolute quantity in itself.

The Abney level is used in a similar manner, but it contains no swinging pendulum, and must be set to the desired grade before the sight is taken to the instrument. Some of the Abney levels are graduated to degrees; others to degrees and slopes, in the proportion of 1:1 and 1:10; others have graduations for per cent. This has led to some confusion, and some bad construction has resulted. Care should be used to apply only the per cent when this instrument is in use on trails.

The Locke level is a simple hand level which does not sight either uphill or downhill; it is used by sending an assistant ahead with a pole, upon which sights are taken through the barrel of the level. Allowance must be made for the height of the surveyor's eye above the ground. Thus, if his eye is 5 feet above the ground he can fix the location of a 5 per cent grade by working

uphill and taking a sight on the ground at a point 100 feet distant, or by sighting downhill at the top of a pole which is 10 feet high and 100 feet distant.

For running different gradients, of course the height of the surveyor's eye remains the same, and the length of the sight is changed according to the grade. Thus, a sight on a 10-foot pole, looking downhill, in a distance of 50 feet, would give a 10 per cent grade; and a sight, uphill, on the ground at a distance of 50 feet, would give a 10 per cent grade, still assuming the height of the surveyor's eye to be 5 feet. In the same manner, if the sights, both uphill and downhill, were 200 feet, the grade would then be  $2\frac{1}{2}$  per cent.

The use of these instruments is to some extent a matter of individual preference.

In the large majority of cases the grade should be located by a downhill survey. This is always the case when a pass or saddle is the salient high point. When the grade connects two salient points the location may be run in either direction. The alignment of the trail, or its meanders, may be determined by a compass survey after the trail is constructed. It is a matter of secondary importance and should be given no consideration if it takes any time which might have been spent in getting the best possible grade. The importance of alignment should not be entirely overlooked, however, and where two or more routes would give equally satisfactory grades, then the one should be chosen which will have the most favorable alignment, together with shortness of distance, and which will require the least number of bridges and culverts, and in other respects afford the most favorable conditions for construction.

### PLATTING THE SURVEY.

When a plane table is used, the survey and platting progress together, but if other methods are used it is necessary to "plat" the notes. This should be done on the prescribed forms, using one of the standard scales which are described on page 66. Be sure that the plat shows the scale, as well as "what it is, where it is, who made it, and the date." If the plat does not "close," throw the error into the sides or angles which are most liable to be inaccurate on account of difficulties in the field work. If local attraction was encountered at one corner the error is likely to be in that angle. If offsets were made, or very rough or steep country traversed on one side, the mistake is probably in the chaining of that side. An error of one link to the chain is allowable. If a larger error appears in platting, the field work *must* be repeated.

### MAP MAKING IN THE FIELD.

After the salient points of the topography have been located by plane table, and the roads, streams, or summits have been traversed by compass surveys, it remains for the surveyor to sketch in the contours. Some of this may be done when the peaks are located and when the distances are chained, and the result is a skeleton map upon which it remains to fill in the balance by the eye. This is a matter of practice. It is an excellent plan to learn to read contour maps, such as are published by the Geological Survey, and the student should provide himself with a topographic sheet of some region with which he is well acquainted and learn to

identify the relief with its contours. When this is mastered a good contour map will be almost as graphic as a miniature model of the country.

In sketching contours it is of great assistance to imagine the sea level raised. Thus, if the 5,000-foot contour is being sketched, we may imagine that the salt waters of the earth are raised 5,000 feet higher than they now are. It is evident that the true contour would follow the shore line which is thus imagined and that bays and harbors, islands, straits, etc., would result. It is evident that contour lines can not cross each other or themselves and that they must connect somewhere, either on the map which is being prepared or in some other region.

The contour map, when thus prepared, is only a base map for other data to be collected for the Forest Service. Some of this data may be collected as the survey proceeds, such as the classification of the land, timber, woodland, barren, etc., or the composition and stand of a forest. When the plane-table map is being made in the field, the paper is necessarily covered with pencil notes and lines which give the names of points, elevations, directions, etc. There is no need to encumber this map with other figures or names which may be confusing or lead to error. A better plan is to cover the map with a piece of tracing cloth, with the dull side up, which may be thumb-tacked along one side only, that it may hang back out of the way when work is being done on the base map. On this the burns, windfalls, barren areas, or stand may be sketched either in black or with colored crayons without smearing the base

map or obliterating any of its topographic data. Some salient points on the base map should be copied on the tracing cloth so that the two may be registered at any time, for the paper may shrink or the cloth may stretch.

### THE FOREST ATLAS.

The *Forest Atlas* at Washington is the central depository for maps, diagrams, statistics, and history of the National Forests and forestry in general throughout the world. Its most important division is that of maps, and the most important maps are those of the National Forests.

The Forest Atlas now comprises 190 volumes, containing *sheets* exactly 18 by 21 inches. They are bound in loose-leaf holders in two ways. *Standard binders* have the binding margin on the 21-inch side, while *township binders* have the binding margin on the 18-inch side. No map is made on a sheet less than 18 by 21 inches, and larger maps are made on two or more sheets which are always numbered from west to east beginning at the northwest corner. Borders are omitted. The title consists only of the name of the forest or the number of the township. The top of the map is always north. A binding edge of at least  $1\frac{1}{2}$  inches is always left blank on the west or left-hand side of each sheet.

The *standard scale* of the Forest Atlas is 1 inch to 1 mile, and the National Forests have been practically covered by atlas sheets according to this standard. Whenever, in special cases, a larger or smaller scale is necessary for the preparation of any map in the Forest Service, it must sustain the simple relation of  $\times 2$



or  $\div 2$ . Thus the scale may be 2 inches, 4 inches, or 8 inches to 1 mile; or  $\frac{1}{2}$  inch,  $\frac{1}{4}$  inch, or  $\frac{1}{8}$  inch to 1 mile. Under no circumstances will sheets be prepared for the Forest Atlas on the ratio of 3, 5, 7, etc. The scale of *township plats* is 2 inches to 1 mile, because that scale was adopted by the General Land Office, from which the plats were procured.

The Atlas sheets which cover a National Forest are called a *folio* and are assembled, with a *legend page*, in a paper cover, on which is printed an *index diagram* showing the number of the sheets.

In the office of each district forester is a *District Atlas* consisting of 20 or more volumes, containing duplicate sheets of the Forest Atlas covering the area of the district. Whenever Forest Atlas folios have been duplicated by photolithography or otherwise for a National Forest, the officers have been supplied with copies, but under no circumstances are copies of any atlas folio to be sold or given away. They are strictly for the use of forest officers in the administration of the National Forests. Copies for distribution are not published.

Forest Supervisors are supplied by the property clerk with binders for Forest Atlas folios, having the binding margin on the 21-inch side, and also with binders for Land Office township plats, having the binding margin on the 18-inch side.

The folios are the "mother maps" which furnish the bases from which further map making will proceed in the Forest Service. They correspond to the mother maps of other countries in this respect—that they are compiled from official data upon a standard scale, 1

inch to 1 mile,<sup>1</sup> and upon a uniform legend. They are not always sufficiently accurate for forest work, and the sheets must, therefore, be corrected whenever new data have been obtained in the field. The manner of correcting sheets is shown on the "dummy Atlas sheet," which has been issued to forest officers. The method is that used by printers in correcting proof. Bold lines should be drawn to the margin of the sheet and explanatory notes written clearly. Do not make neat corrections without the marginal note, or it will not be apparent that the sheet has been corrected. Do not write letters or memoranda telling how a sheet should be corrected. Do it yourself. Do not be afraid to mark up any sheet because it is beautifully engraved or colored. Your corrections will make it more valuable.

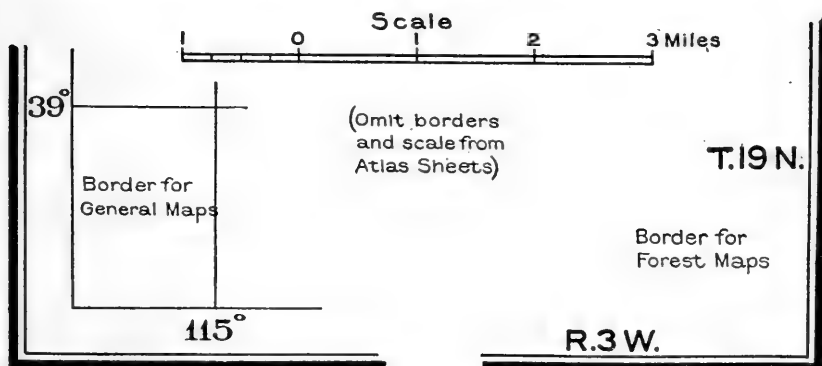
New data obtained by reconnaissance is usually mapped on a scale of 2 inches or 4 inches to 1 mile. Such data should not be redrawn to the standard Atlas scale in the field. The reconnaissance tracings should be sent to Washington with a requisition, Form 988, for photoreduction. For this and other reasons reconnaissance tracings and other base maps should be drawn with black ink only, and should show only the drainage, contour, culture, and land lines. Other data, such as classification, forest or grazing types, or administration districts, can be shown by appropriate colors upon two or more prints. By this method the tracing remains a record which is subject to very little change,

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<sup>1</sup> The mother maps of Great Britain and India are on the same scale as the Forest Atlas standard. Those of France, Spain, Italy, Switzerland, and Sweden are nearly the same,  $1\frac{1}{4}$  inches to the mile. Those of Bosnia, Herzegovina, Norway, Bulgaria, Hungary, Russia, and Portugal are on smaller scales; those of Germany, Belgium, Denmark, and the Netherlands are on larger scales.

## CONVENTIONAL SIGNS

|  |                           |        |                           |
|--|---------------------------|--------|---------------------------|
|  | Wagon road                |        | Hotel                     |
|  | Secondary road            |        | Store                     |
|  | Trail                     |        | School                    |
|  | Railroad                  |        | Church                    |
|  | Telegraph line            |        | Cemetery                  |
|  | Telephone line            | ■ TEL  | Telegraph office          |
|  | Power line                | ■ TLP  | Telephone office          |
|  | Pipe line                 |        | Cabin                     |
|  | Aqueduct                  |        | Logging camp              |
|  | Fence                     |        | Sawmill, portable         |
|  | Ditch                     |        | Sawmill, stationary       |
|  | Flume                     |        | Grist mill                |
|  | Bridge                    |        | Grist and sawmill         |
|  | Corral                    |        | Apiary                    |
|  | Supervisor's headquarters |        | Windmill                  |
|  | Ranger's hq's, no house   |        | Well                      |
|  | Ranger's hq's, with house |        | Quarry or gravel pit      |
|  | House                     |        | Mine location, unpatented |
|  | Railroad station          |        | Mine shaft                |
|  | Stage station             |        | Triangulation station     |
|  | Power station             | X B.M. | Bench mark                |
|  |                           | 1232   |                           |



## LETTERING.

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**ABCDEFGHIJKLMNOPQRSTUVWXYZ**  
**abcdefghijklmnopqrstuvwxyz 123456789**

(topography)

UPPER CASE USED FOR TITLES MOUNTAIN RANGES, STATE NAMES, TOWNSHIP AND RANGE NUMBERS, GRANTS, AND RESERVATIONS, ALPHANUMERIC SYMBOLS.

Upper and Lower Case for Peaks, Valleys, Islands, Capes, etc., Meridians and Parallels, Legends and Scales.

---

**A B C D E F G H I J K L M N O P Q R S T U V W X Y Z**  
**a b c d e f g h i j k l m n o p q r s t u v w x y z 1 2 3 4 5 6 7 8 9**

(culture)

UPPER CASE FOR RAILROADS, ROADS, TELEPHONE LINES, AND OTHER MEANS OF COMMUNICATION.

*Upper and Lower Case for Other Culture.*

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**ABCDEFGHIJKLMNOPQRSTUVWXYZ**  
**abcdefghijklmnopqrstuvwxyz 123456789**

(settlement)

UPPER CASE FOR CITIES, STATE, AND COUNTY BOUNDARIES.

Upper and Lower Case for Towns, Villages, Post Offices.

---

**ABCDEFGHIJKLMNOPQRSTUVWXYZ**  
**abcdefghijklmnopqrstuvwxyz 123456789**

(water)

UPPER CASE FOR OCEANS, LARGE RIVERS, LAKES, ETC.

*Upper and Lower Case for Small Rivers, Creeks, Springs, Marshes, Glaciers, Canals, Ditches, etc.*

and is not obscured by data which is of special rather than general value. The first reconnaissance of any area should include the drainage and contour, otherwise it will not be possible to "register" a second or supplemental reconnaissance with it.

General maps, showing an entire Forest or region are compiled at Washington from data on the corrected Atlas sheets, and are issued for the use of forest officers. The usual process is photolithography. Every request for the issuance of a map should be submitted to the Forester with a recommendation regarding the data to be shown or omitted, scale, kind of paper, and number of copies required. Any project for the issuance of a "three-color map" with blue drainage, brown contours, and black culture should be taken up by correspondence with the Forester before the final tracings are prepared, in order that the manuscript may be in good shape for the engraver.

The Forest Atlas legend page, which has been supplied to all forest officers, shows the standard scheme of colors and symbols which are used in the preparation of all atlas sheets.

It should be borne in mind that National Forests are established in widely different regions; as far north as Alaska and as far south as Florida and Porto Rico. On no two forests will the data suggested on the legend page be of equal importance, and it may be necessary or convenient to adopt additional symbols or colors to show unusual conditions. This is quite permissible providing the marginal notes are made explanatory or if the sheet is subject to only one interpretation by forest officers who will have to use it.

An atlas sheet or any other map should show plainly the information it is intended to convey, and artistic flourishes, fancy type, or border designs are useless. It should show what it is, where it is, the scale, who made it, and the date. It should show also by whom the field examination or survey was made and the date of the same. If it is from an original survey the magnetic variation should be given. On the borders of the map, if the area shown covers more than one township, the township and range numbers should be given, and also, if possible, one or more meridians and parallels. If a degree meridian does not fall in the map, then some intermediate may be given, such as 10' or 20'. Table 7 will be found convenient.

TABLE 7.—*Lengths of degrees on meridians and parallels at different latitudes on the earth.*

| At latitude— | Length of 1°<br>on meridians. | Length of 1°<br>on parallels. | Convergence in<br>one township<br>or in two<br>meridians 6<br>miles long and<br>6 miles apart. |
|--------------|-------------------------------|-------------------------------|--|
|              | <i>Miles.</i>                 | <i>Miles.</i>                 | <i>Links.</i>  |
| 26°          | 68.84                         | 62.21                         | 35.4   |
| 27           | 68.85                         | 61.68                         | 37.0   |
| 28           | 68.86                         | 61.12                         | 38.6   |
| 29           | 68.87                         | 60.55                         | 40.2   |
| 30           | 68.88                         | 59.96                         | 41.9   |
| 31           | 68.89                         | 59.34                         | 43.6   |
| 32           | 68.90                         | 58.72                         | 45.4   |
| 33           | 68.91                         | 58.07                         | 47.2   |
| 34           | 68.92                         | 57.41                         | 49.1   |
| 35           | 68.93                         | 56.72                         | 50.9   |
| 36           | 68.95                         | 56.03                         | 52.7   |
| 37           | 68.96                         | 55.31                         | 54.7   |
| 38           | 68.97                         | 54.58                         | 56.8   |
| 39           | 68.98                         | 53.83                         | 58.8   |
| 40           | 68.99                         | 53.06                         | 60.9   |
| 41           | 69.01                         | 52.28                         | 63.1   |
| 42           | 69.02                         | 51.48                         | 65.4   |
| 43           | 69.03                         | 50.67                         | 67.7   |
| 44           | 69.04                         | 49.84                         | 70.1   |
| 45           | 69.05                         | 49.00                         | 72.6   |
| 46           | 69.07                         | 48.14                         | 75.2   |
| 47           | 69.08                         | 47.26                         | 77.8   |
| 48           | 69.09                         | 46.37                         | 80.6   |
| 49           | 69.10                         | 45.47                         | 83.5   |

The atlas sheets show the alienation of lands within National Forests, but it must be understood that data of this kind can not be accepted as final authority, but may be regarded as presumptive evidence. It has required three years to collect the alienation data for the National Forests, and since their status changes from day to day, while the compilation and publication of atlas sheets requires several months, it is evident that a folio can not be issued to forest officers which will be up to date in this respect. It is only by keeping new data posted on the sheets that the office record can be kept up to date.

Maps are never perfect, nor do they approach perfection unless repeatedly altered and corrected in accordance with discoveries or changed conditions. Although the Forest Atlas sheets are compiled in every case from the best data available, they are often far below the standard which should obtain in forest maps. It will not be regarded as a reflection upon the compiler of a sheet if a large number of corrections are found necessary, and field officers should never hesitate, for this reason, about sending in data.

The coloring tints which are used in the classification scheme may be prepared as follows from standard inks that will be furnished by the property clerk at Ogden, upon requisition:

*Forest Atlas—Color prescriptions.*

Timberland:

| Less than 2,000 board feet per acre— | Parts. |
|--------------------------------------|--------|
| Green ink.....                       | 2      |
| Yellow ink.....                      | 1      |
| Water.....                           | 3      |

## Timberland—Continued.

|  |        |
|--|--------|
| 2,000 to 5,000 board feet per acre—            | Parts. |
| Green ink.....                                 | 1      |
| Water.....                                     | 3      |
| 5,000 to 10,000 board feet per acre—green ink. |        |
| 10,000 to 25,000 board feet per acre—          |        |
| Brown ink.....                                 | 3      |
| Green ink.....                                 | 3      |
| Yellow ink.....                                | 2      |
| 25,000 to 50,000 board feet per acre—          |        |
| Brown ink.....                                 | 4      |
| Green ink.....                                 | 2      |
| Yellow ink.....                                | 1      |
| Water.....                                     | 7      |
| Woodland, cordwood, etc.:                      |        |
| Green ink.....                                 | 1      |
| Yellow ink.....                                | 2      |
| Water.....                                     | 8      |
| Chaparral or brush:                            |        |
| Brown ink.....                                 | 1      |
| Water.....                                     | 5      |
| Sagebrush:                                     |        |
| Brown ink.....                                 | 3      |
| Yellow ink.....                                | 2      |
| Orange ink.....                                | 2      |
| Water.....                                     | 10     |
| Grassland, parks, etc.:                        |        |
| Yellow ink.....                                | 1      |
| Water.....                                     | 1      |
| Barren land:                                   |        |
| Black ink.....                                 | 1      |
| Water.....                                     | 20     |
| Burn, forest cover established:                |        |
| Green ink.....                                 | 1      |
| Yellow ink.....                                | 2      |
| Water.....                                     | 8      |



|                                  | Parts. |
|----------------------------------|--------|
| Old cuttings:                    |        |
| Brick-red ink.....               | 1      |
| Water.....                       | 3      |
| Cultivated—red ink.              |        |
| Mineral lands—orange ink.        |        |
| Open for cattle and horses only: |        |
| Brick-red ink.....               | 1      |
| Water.....                       | 3      |
| Open for sheep and goats only:   |        |
| Yellow ink.....                  | 1      |
| Water.....                       | 1      |
| Closed for all stock—orange ink. |        |
| Driveways for stock:             |        |
| Black ink.....                   | 1      |
| Water.....                       | 20     |

When timber or woodland has been partly burned, the lining for burns may be used on top of the green. When partly cut over, or culled, the proper signs may be used in the same manner.

## FOREST ATLAS CRAYONS.

In order to secure uniformity in coloring field maps, boxes containing 12 crayons are furnished, with a descriptive label, for use with the Forest Atlas legend. They are as follows:

## COLORED CRAYONS.

*General classification.*

|  |  |
|--|--|
| 69. Less than 2,000 B. F.              | 2. Grassland, parks.                     |
| 29. 2,000 to 5,000 B. F. (light).      | 6609. Barren, above timber line,<br>etc. |
| 29. 5,000 to 10,000 B. F. (heavy).     | 63. Burn, forest cover estab-<br>lished. |
| 15. 10,000 to 25,000 B. F. (light).    | 72. Old cuttings.                        |
| 15. 25,000 to 50,000 B. F. (heavy).    | 46. Cultivated.                          |
| 63. Woodland, cordwood, poles,<br>etc. | 62. Mineral.                             |
| 87. Chaparral or brush.                | 58. Water.                               |
| 37. Sagebrush.                         |  |

*Grazing map legend.*

- |                                |                             |
|--------------------------------|-----------------------------|
| 58. Administrative divisions.  | 2. Open for sheep and goats |
| 72. Open for cattle and horses | only.                       |
| only.                          | 62. Closed for all stock.   |
|                                | 87. Driveways for stock.    |

The property clerk has installed a machine for printing the Forest Atlas legend upon each colored crayon, and it is expected that this improved method of marking will lead to greater accuracy in the use of colors on maps. There have always been some uncertainties, due to the fact that many men are not good judges of color, and also because the makers of colored crayons change the formulæ for mixing colors or use different grades of pigment. It has also been found in the case of some colors that they change materially with age. Under this new method of marking it will be possible for the property clerk to obtain in each case the best grade of a standard color, and, disregarding the manufacturer's number, print the atlas legend upon the pencil. Thus, the bright yellow crayon will be marked "Grassland, parks, etc.," and "Open for sheep and goats only."

On important work a legend showing the colors and symbols used and their significance should accompany each map or folio.

**MOUNTING MAPS ON MUSLIN.**

Slightly dampen the muslin and stretch it over a table top or other flat surface. Fasten with tacks not more than 4 inches apart. Wet the map thoroughly by dipping it in water or with a sponge. Remove surplus

water with large blotters. Lay the map face down upon the muslin, and with a wide flat brush (rubber bound) apply paste quickly but evenly over the back of the map. Turn over the map and press it smoothly upon the muslin, using a blotter and roller. Leave it to dry overnight. The hands should be wet when handling a wet map and the surface of the map should be rubbed as little as possible. It is better for two persons to work together, holding all four corners of the map and allowing it to fall upon the muslin from the center toward the corners, thus avoiding air bubbles. If any paste gets upon the face of the map it should be immediately removed with a wet sponge.

Three or four layers of maps may be mounted on the same board, provided a dry piece of muslin (same size as map) be placed between the layers.

In some instances, for convenience in folding to pocket or other small size, the map should be cut into sections, all of the same size and shape, and mounted with a slight break between each section, where the fold will come. In this case, each small sheet must be placed separately upon the big sheet of muslin, which has been previously dampened slightly.

One gallon of paste may be made as follows: Dissolve  $1\frac{1}{2}$  pounds of lump starch in 1 gallon of water. Then stir constantly while pouring boiling water over it until the mixture becomes thick. Set aside, and when almost cold squeeze through a piece of cheesecloth in order to remove the lumps.

# METHOD OF USING THE FOREST SERVICE STANDARD PLANIMETER.

Planimeters are issued to some forest officers and are used to determine areas platted on maps. They are constructed to register areas in square inches and deci-

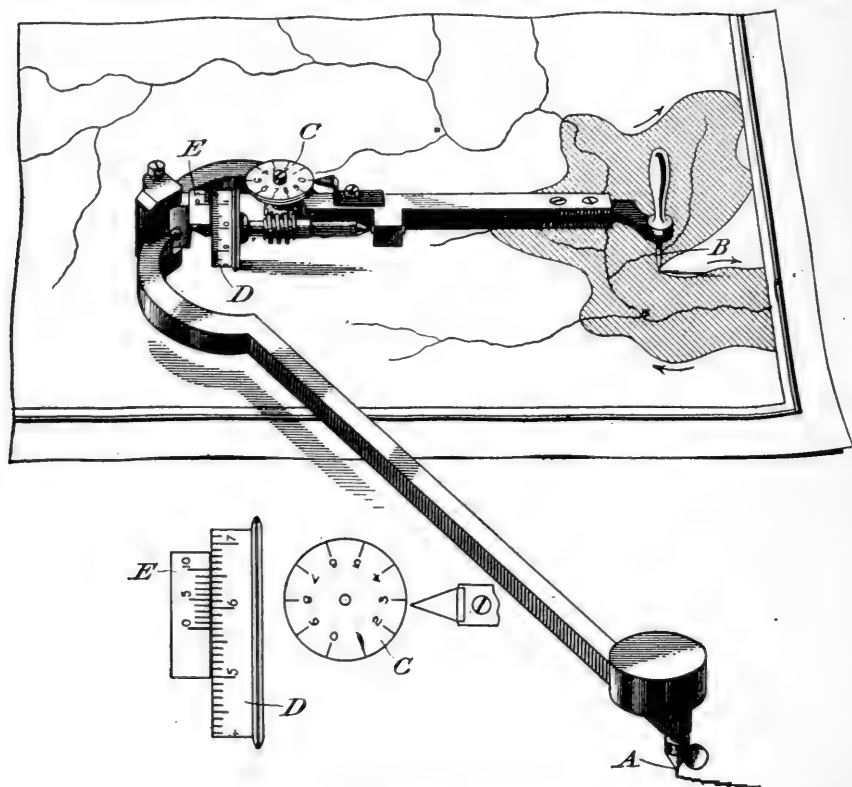


FIG. 12.—Standard planimeter.

imals of 1 square inch and are used in the following manner:

(1) Place the weighted stationary pin, *A*, figure 12, *outside* of the area to be determined, below and to the left, in a position which will permit the “tracing pin,”

*B*, to follow the entire outline freely. If the area to be determined is too large to permit placing the stationary pin outside, and thus determining the area as a whole, the area may be divided and its parts determined separately.

(2) Place the tracing pin at any starting point on the outline of the area and press it in to make a distinct mark on the surface. Set all the scales at zero with the hand. Then draw the tracing pin around the outline of the area, following it as exactly as possible, until the circuit is completed and the tracing pin rests at the starting point. The circuit must be made in the same direction that the hands of a watch move.

(3) Four figures, representing tens, units, tenths, and hundredths, may be read after the circuit is completed, and the reading may be from 00.01 to 99.99. Figure 12 shows a sample reading of 25.71 square inches because the dial *C* registers 10 square inches for each numbered division. The roller *D* registers 1 square inch for each numbered division. The vernier *E* registers 0.01 square inch to be read against *D*.

It will be noted that the pointer at dial *C* points between 2 and 3. The area in square inches is, therefore, between 20 and 30. The zero on the vernier *E* serves as a pointer for the roller *D*. This reads between 5 and 6. Therefore the integral area is 25. Counting the divisions between the figures 5 and 6, it is seen that the zero on the vernier barely passes the seventh mark. Therefore the first decimal is 0.7. By looking along the vernier *E* it will be seen that one of the graduations falls exactly opposite one of those on

roller *D*. This will happen in every case and the number of this mark on the vernier will determine the second decimal. In the diagram the first mark to the right of the zero falls opposite a mark on roller *D* and therefore the reading is 0.01. Thus the total reading is 25.71 square inches. Use a magnifying glass if necessary.

(4) The area in acres is found by multiplying the figure given by the planimeter by coefficient determined by the scale on which the map is drawn. If the scale be 1 inch to the mile, 1 square inch will represent 640 acres. If it be one-half inch to the mile, 1 square inch will represent 4 square miles and the acreage will be determined by multiplying the instrument reading by  $640 \times 4$ , or by 2,560. If the scale be 2 inches to the mile, 1 square inch will represent 160 acres; and so on for any desired scale.

(5) Blueprints and other photographic papers are never exactly to scale, but a conventional mile on the print can be planimetered, and the reading thus obtained will be known to represent 640 acres.

(6) On important work the area should be planimetered several times and the results averaged.

(7) For practice, a regular figure, such as a square containing a known number of square inches, should be planimetered until the reading on the instrument agrees substantially with the known area.

(8) Only an expert should attempt to adjust a planimeter. If the instrument does not work properly it should be returned to the property clerk for repairs.

## LAND OFFICE SURVEYS.

The rectangular surveys of the United States Land Office control throughout the West and divide the land

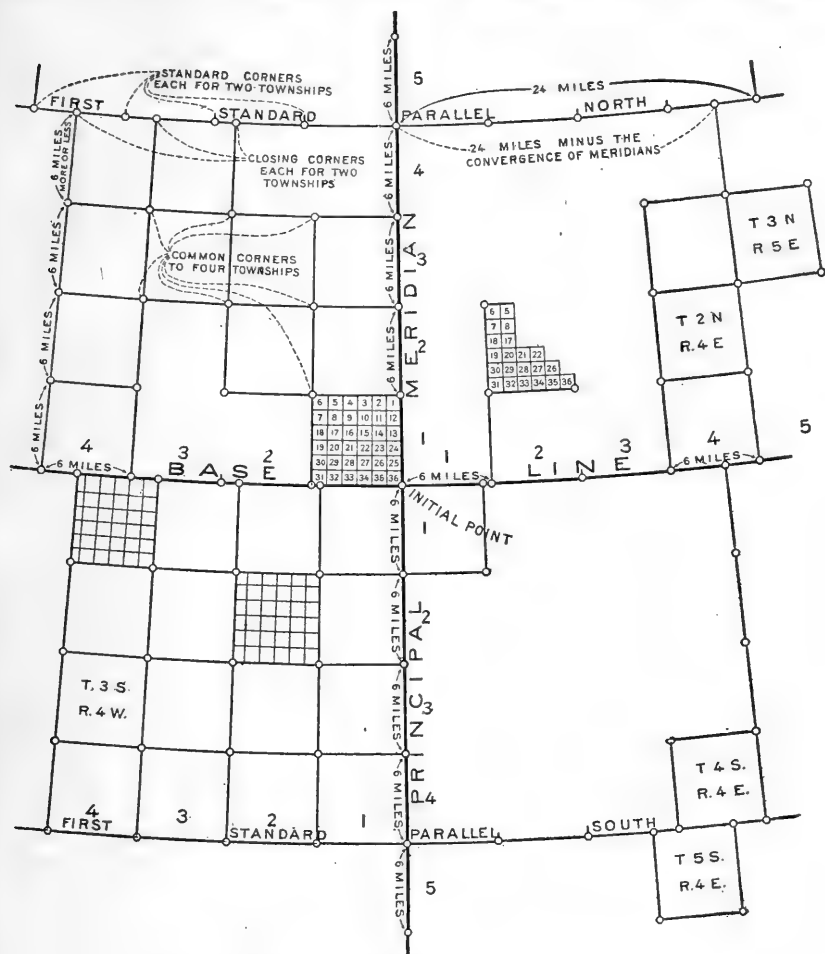


FIG. 13.—Rectangular system of Land Office surveys.

surfaces into squares, which may be divided and subdivided, quartered, quarter-quartered, etc. The unit

of the system is the township, which is, conventionally, 6 miles square and contains 36 sections of 640 acres each, or 23,040 acres.

Inasmuch as meridian lines converge toward the North Pole, it is evident that townships will have a trapezoidal form and that they will materially decrease in area toward the north unless correction lines are introduced. The system is as follows (see fig. 13, p. 81):

Beginning at the initial points, a base line is run due east and west with standard parallels 24 miles distant. From these parallels guide meridians, 24 miles distant, are run due north and "close" on the standard parallels. This divides the region into tracts 24 miles square, except for the convergence mentioned. Then township lines are run, making tracts which are 6 miles square. These are afterwards "subdivided" into sections. The conventional section is legally subdivided into quarters and quarter-quarters, and by common usage into smaller subdivisions, but unless otherwise specified these are all proportionate areas to the quarter section. A conventional section is cut into quarters by straight lines which connect the quarter corners on its boundaries.

Whenever, as in the case of timber sales, it becomes necessary to survey and mark a line which bounds some alienation, it is important that the line should be either legally correct or should be agreed to in writing by the private owner for the purpose of the sale, and in case of a disagreement no timber should be marked for cutting in the disputed strip until the merits of the case have been submitted to the Forester and his instructions received.



There are many exceptions to the simple rectangular scheme as outlined above, and many different anomalous townships and sections result from methods which have to be employed in special cases.

### RESURVEYS.

When a survey is to be made in a township which has been subdivided, or when the lines of old survey boundaries are to be retraced, the prime object is to *follow* all of the legal lines and to check up on all of the legal corners. For this purpose the surveyor should know:

- (1) The date when the original survey was made.
- (2) The variation used.
- (3) The change in variation, increase or decrease, since the original survey was made.

In any Western State this information may be obtained from the surveyor general, and usually from the county surveyor of the county in which the survey is to be made. In any event the new variation, as determined by the resurvey, should be entered in the field notes for future reference.

### CANCELLATION OF MISLEADING MARKS ON FORMER FOREST BOUNDARY POSTS.

Forest officers are cautioned that the agreement between the General Land Office and the Forest Service in regard to the cancellation of certain misleading markings on National Forest boundary posts does not extend to any of the existing regulations against changing the markings on any posts other than as herein specified

Owing to changes in some National Forests many of the metal posts used to mark the boundaries, as surveyed by the Geological Survey and approved by the General Land Office, have become misleading. As these posts usually mark section corners, and also furnish valuable points for reference, they must not be removed, but their misleading marks may be canceled. This will be done by cutting, with a sharp cold chisel, a line through any misleading word or words, the intention being to cancel them without rendering them illegible.

On no account shall any portion of the markings which are still true, or partly true, be thus canceled. For example, in the following cases, the words which, in a National Forest, may be canceled are shown.

**~~AQUARIUS~~ FOREST RESERVE ~~BOUNDARY~~ POST NO. 27.**

**BLACK HILLS ~~BOUNDARY~~ POST NO. 18:**

**UNITED STATES FOREST RESERVE ~~SAN JACINTO~~ ~~BOUNDARY~~ POST NO. 43.**

Outside of a National Forest the words which, for example, may be canceled are shown thus:

**UNITED STATES ~~FOREST RESERVE~~ ~~MADISON~~ ~~BOUNDARY~~ POST NO. 37.**

In every case when any mark on a post is canceled the same cancellation must be made on the bearing trees if their marks are misleading, by cutting a groove across the word.

A report must be made to the Forester giving the location and number of each post canceled and stating which of the markings thereon have been canceled.

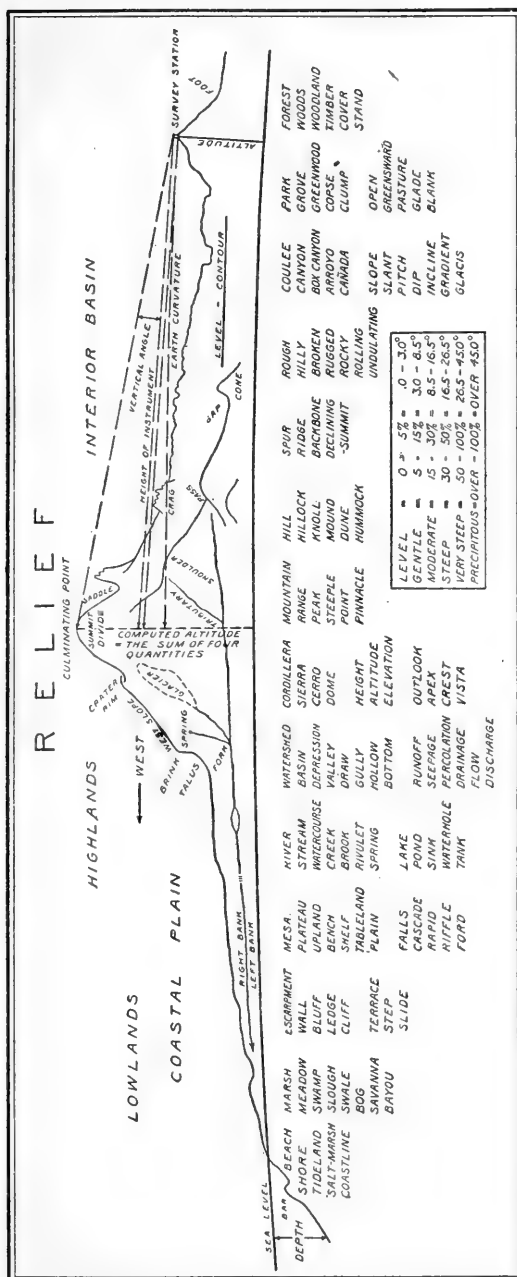
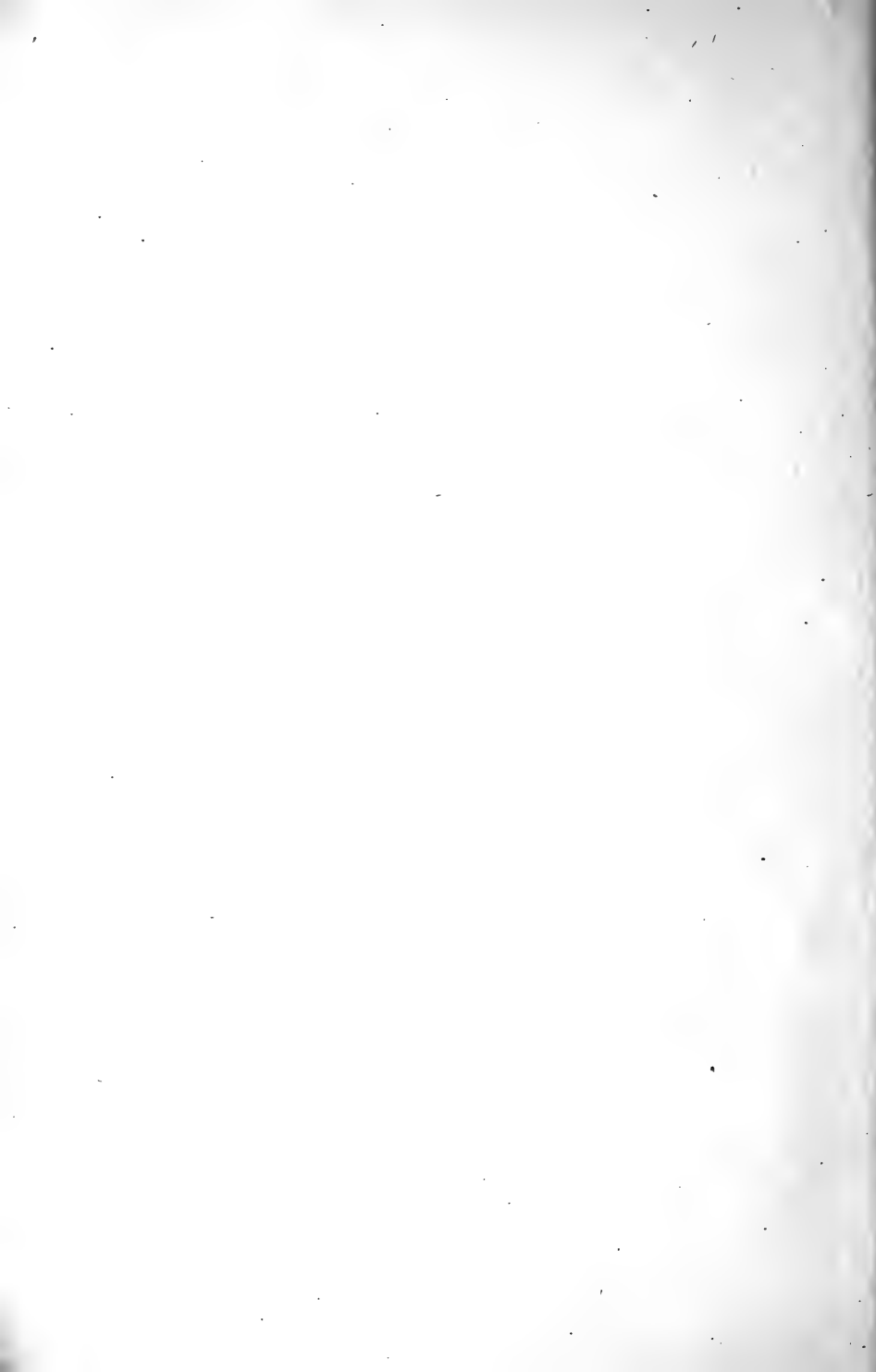


Fig. 14.—Names of physiographic features.



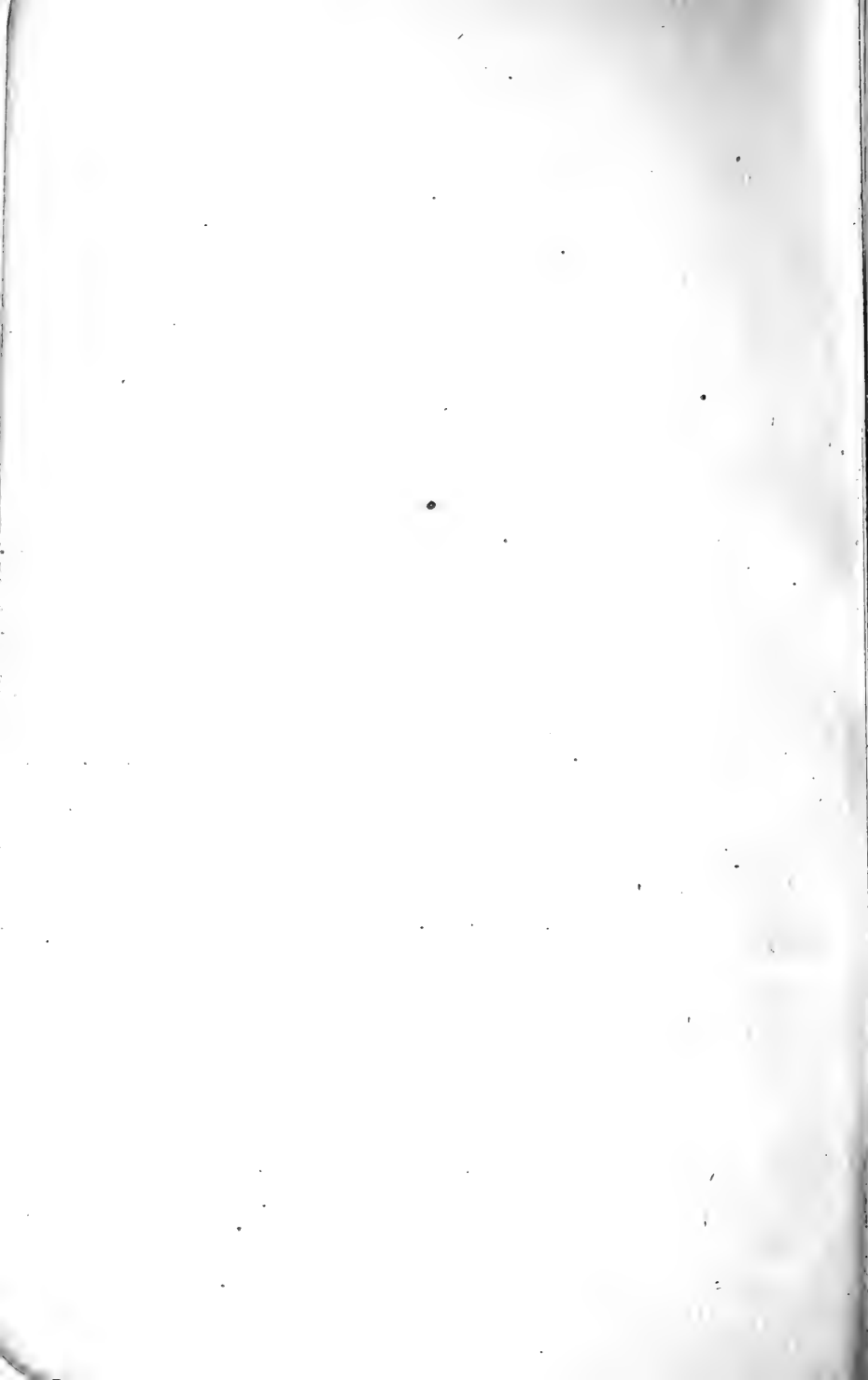
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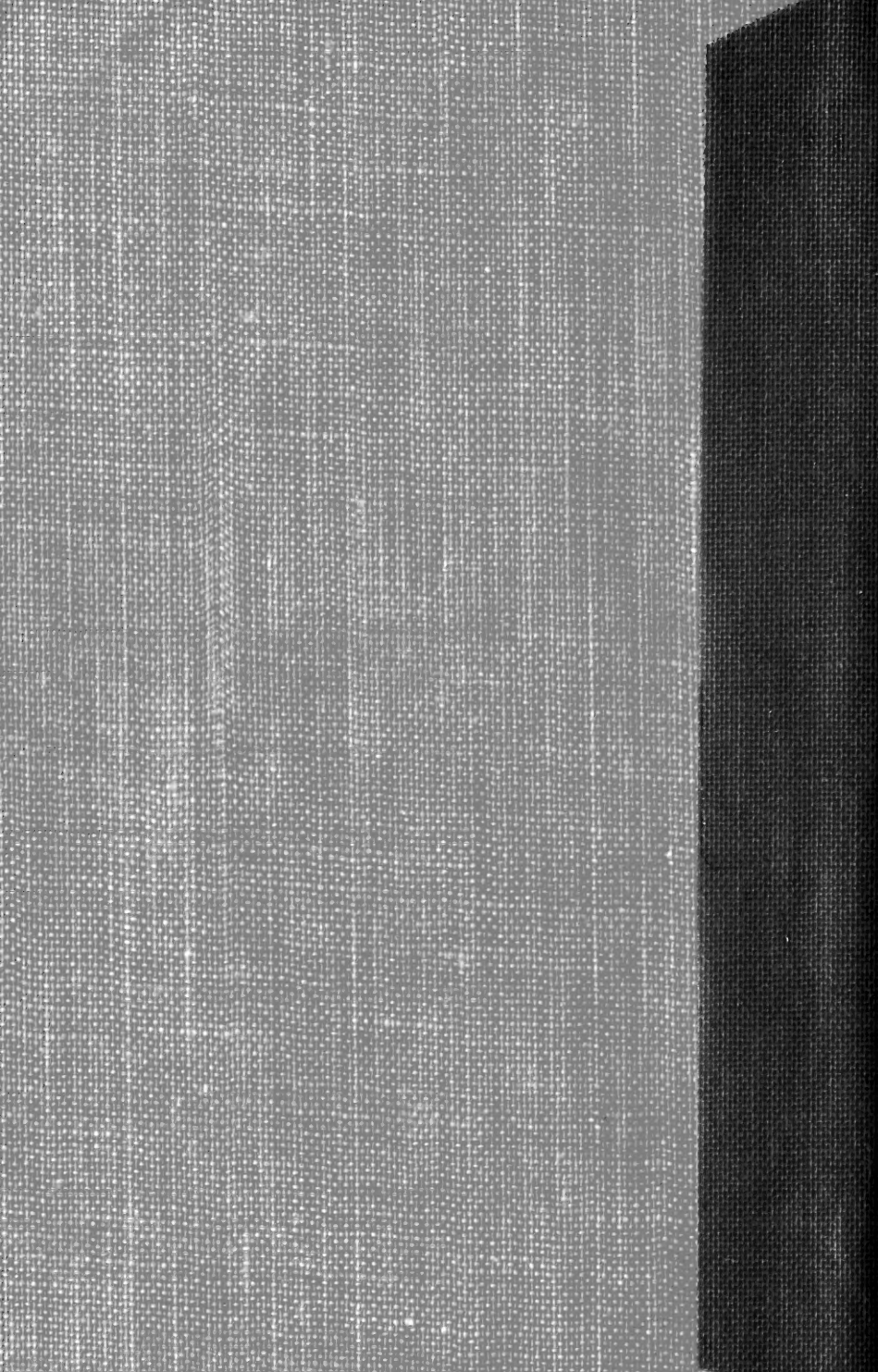




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